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EFFECT OF LIGHT, TEMPERATURE, AND HORMONES ON THE REPRODUCTIVE PERFORMANCE OF EWES [1, 2]

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PRODUCTION of lambs for early spring marketing is one of the major problems confronting sheep producers in many sections of the United States. Since it is generally accepted that ewes of most breeds will breed only in the fall, the production of early lambs requires that ewes be bred at times other than the normal breeding season.

Earlier studies (Sykes and Cole, 1944; Hammond, 1944; Yeates, 1949; Hart, 1950) have suggested that the amount of light to which ewes are exposed has an influence on the estrous cycle, with decreasing amounts of light being the stimulating factor. Cooler temperatures are usually associated with shorter days, and may play an important part in the onset of the breeding season.

The possibility of using various hormones or hormone extracts to induce estrus in the anestrous ewe was explored by Cole and Miller (1933), Bell *et al.* (1941), Hammond *et al.* (1942), Cole *et al.* (1945), Hammond (1945), Frank *et al.* (1945), Vander Noot *et al.* (1949), Dutt (1953), Denny and Hunter (1958), Hunter *et al.* (1958), and Robinson (1958). These investigations in general show that the use of hormones fails to produce synchronous estrus and ovulation consistently.

The purpose of this experiment was to study the effect of light, temperature and hormones on breeding performance and early lamb production.

Experimental Procedure

One hundred grade Rambouillet ewes were randomly assigned to five lots of 20 ewes each. The lots were randomly assigned to treatments and ewes remained on the same treatment for three breeding seasons. Death losses and ewes failing to exhibit estrus were replaced prior to the second and third breeding seasons with ewes of the same origin. The breeding season extended every year (1956–1958) from April 25 through June 15. This 52-day period gave all ewes time for at least three estrous cycles. Ewes in lot I were penned in a dark room a part of each day in order that the hours of light they received simulated October conditions. Air circulation was maintained by an exhaust fan which could be regulated to run continuously or part time as needed. The length of day was decreased by enclosing the ewes prior to sunset and turning them out after sunrise. At the beginning of the breeding season, these ewes were limited to 11.4 hours of daylight and the daylight hours were decreased, by 6 minutes every fifth day, to 10.4 hours at the end of the season. During this same period the normal length of daylight had increased from 13.4 to 14.4 hours. Ewes in lot II were housed in an air-conditioned room where the temperature was controlled to simulate October temperatures. Beginning on April 25, the temperature was maintained at 70° F. and lowered 1° F. every fifth day. The temperature in this room was 60° F. at the end of the breeding season. The temperature was controlled within 2° F. of the desired level. Lot III ewes were housed in a room in which both October temperature and light conditions were simulated. Lot IV ewes were injected with 30 mg. of progesterone [4] on April 23, and thereafter at 3-day intervals until they had received 5 injections. This was followed by an injection of 500 IU of pregnant mare serum [5] 3 days later (May 8). Lot V was the control group. Lots IV and V were kept on pasture throughout the breeding seasons. The average maximum temperature was 85° F., and the average minimum was 59° F. during the breeding seasons.

During the first breeding season, the ewes in all lots were bred by natural service using Suffolk rams. Marking-harnesses with colored crayon were put on the rams at night to fa-

[1] Technical Contribution No. 337, South Carolina Agricultural Experiment Station. Supported in part by funds from the Southern Regional Project, S-29, "Improving the Production of Early Milk Fat Lambs", a cooperative study by agricultural experiment stations in the southern region and the USDA.

[2] A portion of the dissertation presented by the senior author to the Graduate School of the Clemson Agricultural College, Clemson, S. C. in partial fulfillment of the requirements for the M.S. Degree.

[3] Research Assistant in Animal Husbandry, Animal Husbandman, and Dairy Husbandman, respectively.

[4] Crystalline progesterone with repository base (Norden Laboratories, Inc.).

[5] Five hundred International Units of pregnant mare serum in the form of the commercial preparation, Gonadin.

cilitate the detection of estrus and copulation. The harnesses were removed and the rams separated from the ewes during the day. At the end of each 15-day period, the color was changed in order that ewes in return estrus could be detected. All ewes were bred by artificial insemination during the second (1957) and third (1958) breeding seasons. Semen was collected by the use of an artificial vagina and extended at a rate of 1 to 20 in an egg-yolk sodium citrate extender immediately after collection. Ewes were checked for estrus twice daily using sterile rams. Those ewes showing estrus were inseminated immediately following initial detection and a second insemination was made 12 to 16 hours later. At each insemination, 1.0 cc of extended semen was placed in the cervix or as near to it as possible. Semen storage, at 34–36° F., varied from zero to 80 hours with an average storage time of 20 hours.

All ewes were kept and managed as one flock except during the breeding season. Summer grazing was on Bermuda-grass (*Cynodon dactylon*) and millet (*Setaria*) pastures with small grain and fescue (*Festuca*) pastures utilized during the winter.

All data were analyzed by analysis of variance. In order to approximate a normal distribution the percentages were transformed to angles (angle = arc sin $\sqrt{\text{percentage}}$). To test the difference between any two treatment means, Duncan's (1955) multiple range test was used.

Results and Discussion

Number of Ewes Exhibiting Estrus. The percent of ewes in each lot exhibiting estrus for each breeding season is shown in table 1. The control lot had the lowest average percent over the 3-year period. This percent was not significantly lower than those of the other lots; however, it approached significance at the 0.05 level. This indicates that light, temperature, a combination of the two, and hormones may have a stimulating effect on the estrous cycle of sheep.

Year differences over all treatments in percent of ewes exhibiting estrus were not significant. In 1956 and 1958, 100% of the ewes in lot IV were in estrus, whereas only 70% of the ones in this lot came in heat during 1957. There was no apparent reason for the decrease in 1957. During the 3-year period (1956–1958), 4 ewes in lot IV came into estrus while receiving the injections of progesterone. Three of these ewes were again in estrus within 4 days after the injection of PMS. The fourth ewe apparently was not affected by the injection of PMS as estrus occurred at a normal interval. None of the four lambed. The majority (approximately 82%) of the ewes that received injections of hormones were in estrus within 4 days following the injection of PMS.

TABLE 1. PERCENT OF EWES EXHIBITING ESTRUS, BY TREATMENTS AND YEARS

Lot number	Treatment	1956	1957	1958	Mean
I	Light	95	85	90	90
II	Temperature	85	80	95	87
III	Light and temperature	95	95	95	95
IV	Hormone	100	70	100	90
V	Control	85	60	60	68
Mean		92	78	88	

A higher percent (85%) of ewes in lot V were in estrus in 1956 than in 1957 and 1958. This may have been due to the relatively cool spring when the outside temperature at times was lower than the temperature inside the chambers. During the spring of 1956, there were 17 days in which the minimum temperature was 40° F. or below, whereas there were only 10 such days in 1957 and 8 in 1958. The high incidence of estrus in ewes of all treatment groups (90%), compared to the controls (68%), strongly suggests the possibility of inducing early estrus in sheep. This is supported by Hart (1950), who reported that a ratio of 1 part light to 2 parts or more of dark, without gradually decreasing the amount of light received, is sufficient to stimulate the onset of estrus. The temperature results are in agreement with those of Dutt and Bush (1955), although they used lower temperatures (45° to 48° F.) to stimulate reproductive functions in ewes. However, McKenzie and Phillips (1933), using a small number of ewes, found no significant effect on the initiation of estrus by subjecting ewes to temperatures of 44° to 48° F. Hormone injections have proven very effective in inducing estrus, as in this experiment; however, lambing rates have been low.

The most economical and practical method of producing early lambs would be to have sheep that would breed out of season without requiring artificially induced estrus. Hafez (1952) and Watson and Radford (1955) reported differences in the breeding season between breeds under similar environmental conditions. However, results of investigations on the possibility of selecting a strain of early breeding sheep differ (de Baca *et al.*, 1954; Williams *et al.*, 1956).

TABLE 2. PERCENT OF EWES LAMBING, BY TREATMENTS AND YEARS

Lot number	Treatment	1956	1957	1958	Mean
I	Light	90	45	35	57
II	Temperature	58[a]	75	45	59
III	Light and temperature	85	60	50	65
IV	Hormone	60	15	10	28
V	Control	65	16[a]	20	34
Mean		72	42	32	

[a] One ewe died prior to lambing.

Number of Ewes Lambing. Table 2 shows the percent of ewes lambing in each lot by years. In 1956 the ewes receiving controlled amount of light had the highest lambing percent, while in 1957, the lot having the highest lambing percent was the one under controlled temperature conditions. In 1958, a combination of light and temperature was most effective. In 1956, the ewes of lots IV and V had a slightly higher lambing percent than those in lot II. During this breeding season, 85% of the ewes in lots II and V and 100% of those in lot IV were in estrus. Thus approximately, 65%, 76% and 60%, respectively, of the ewes that were in heat in these lots lambed. The results in 1956 were quite promising as 72 of the 100 ewes lambed; however, the lamb crop decreased to 42% in 1957, and to 32% in 1958. This large decrease was highly significant ($P<0.01$). With the exception of the ewes under controlled temperature conditions in 1957 and those of the control lot in 1958, there was a decrease in lambing percent in all lots. The larger number of ewes lambing in 1956 as compared to 1957 and 1958 may have been due to lower minimum temperatures during the breeding season; however, the fact that the ewes were bred by natural service that year and by artificial insemination the other years may have been a major factor.

A significant difference ($P<0.05$) between treatments was found for the number of ewes lambing when the averages for the 3 years were considered. The light, temperature, and light and temperature lots had a significantly higher percent of ewes lambing than the hormone lot. The light and temperature lot was the only group significantly different from the controls. The differences between the control lot and the light lot and between the control lot and the temperature lot, while not significant, were sufficiently large to indicate a possible difference due to these effects. All other treatment comparisons were non-significant.

There were small but non-significant differences in lambing rates (table 3) between

TABLE 3. EWES CONCEIVING ON FIRST, SECOND AND THIRD ESTRUS, BY TREATMENTS AND YEARS

Item	Light			Temperature			Light and temperature			Hormone			Control		
	1956	1957	1958	1956	1957	1958	1956	1957	1958	1956	1957	1958	1956	1957	1958
Number ewes in group	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Number conceived first estrus	15	2	2	11	11	6	14	5	7	12	2	2	13	2	4
Number conceived second estrus	3	4	1	0	3	1	3	4	2	0	1	0	0	0	0
Number conceived third estrus	..[a]	3	4	0	1	2	..[a]	3	1	..[a]	..[a]	0	..[a]	1	0
Number ewes lambing	18	9	7	11	15	9	17	12	10	12	3	2	13	3	4
Number lambs dropped	19	11	8	13	17	11	21	15	10	15	3	2	16	3	4
Number lambs dropped per ewe lambing	1.06	1.22	1.14	1.18	1.13	1.22	1.24	1.25	1.00	1.25	1.00	1.00	1.23	1.00	1.00

[a] No ewes in estrus third time.

treatments. The average number of lambs born per ewe lambing was 1.12, 1.17, 1.18, 1.18 and 1.15 for lots I through V, respectively.

There was very little difference between the 4 treatment lots for number of ewes in estrus; however, the hormone lot was significantly lower in number of ewes lambing.

Conception. The number of ewes conceiving on first, second and third estrus for each treatment and year is shown in table 3. Total conceptions were based upon the number of ewes lambing. No significant difference in percent of ewes bred that conceived during the first estrus was found between treatments; however, the difference between years was highly significant. In 1956, using natural service, 71% of the ewes bred conceived during the first estrus. This is compared to only 28% in 1957, and 24% in 1958, when artificial insemination was used. The number of ewes returning in estrus for a second and third time was larger in 1957 and 1958 than in 1956. The percent of ewes conceiving during the second and third estrus was generally low, as approximately 23% of the ewes bred during the second and third estrus lambed.

Average conception dates over the 3-year period were: lot I, May 20; lot II, May 23; lot III, May 15; lot IV, May 15; and lot V, May 10. Differences in conception dates between the lots were not significant; however, there was a tendency for the ewes in the control lot to lamb earlier. Conceptions occurred throughout the breeding seasons with the average date of conception near the middle of the season.

Summary and Conclusions

Five lots of 20 ewes each were used for a 3-year period to study the effects of light, temperature, light and temperature, and hormones on breeding performance and early lamb production.

All lots receiving treatments had a larger number of ewes exhibiting estrus than did the controls; however, this difference was not significant. In percent ewes lambing, the best results were obtained in 1956 in lot I (light), in 1957 in lot II (temperature), and in 1958 in lot III (light and temperature). For the 3-year period the light, temperature, and light and temperature lots had a significantly higher percent of ewes lambing than the hormone lot; however, only the light and temperature lot was significantly different from the controls. In 1956, using natural service, 72% of the ewes lambed. Artificial insemination was used in 1957 and 1958 and the percent of ewes lambing decreased to 42 and 32%, respectively. This difference between years was highly significant. The relatively cool nights in the spring of 1956 may have contributed, at least in part, to the high percent of ewes lambing, as the control and hormone lots did as well as the temperature lot for this particular year. In 1956 the percent of ewes bred that conceived on first estrus (71%) was significantly higher than in 1957 (28%) and 1958 (24%). Only 23% of all ewes bred during second and third estrus lambed.

Literature Cited

Bell, T. D., L. E. Casida, G. Bohstedt and A. E. Darlow. 1941. Production of heat and ovulation in the anestrous ewe. J. Agr. Res. 62:619.

Cole, H. H., G. H. Hart and R. F. Miller. 1945. Studies on the hormonal control of estrous phenomena in the anestrous ewe. Endocr. 36:370.

Cole, H. H. and R. F. Miller. 1933. Artificial induction of ovulation and oestrum in the ewe during anoestrum. Am. J. Psysiol. 104:165.

de Baca, R. C., A. C. Warnick, G. H. Hitchcock and Ralph Bogart. 1954. Factors associated with the onset of estrus in ewes. Ore. Agr. Exp. Sta. Tech. Bul. 29.

Denny, J. E. F. M. and G. L. Hunter. 1958. Synchronisation of the oestrous cycle in sheep. South African J. Agr. Sci. 1:381.

Duncan, David B. 1955. Multiple range and multiple F tests. Biometrics 11:1.

Dutt, R. H. 1953. Induction of estrus and ovulation in anestrual ewes by use of progesterone and pregnant mare serum. J. Animal Sci. 12:515.

Dutt, R. H. and Leon F. Bush. 1955. The effect of low environmental temperature on the initiation of the breeding season and fertility in sheep. J. Animal Sci. 14:885.

Frank, A. H., R. G. Scholt and V. L. Simmons. 1945. Response of anestrous does and ewes to pregnant mare's serum during two consecutive seasons. J. Animal Sci. 4:317.

Hafez, E. S. E. 1952. Studies on the breeding season and reproduction in the ewe. J. Agr. Sci. 42:189.

Hammond, J., Jr. 1944. On the breeding season in the sheep. J. Agr. Sci. 34:97.

Hammond, J., Jr. 1945. Induced ovulation and heat in anestrous sheep. J. Endocr. 4:169.

Hammond, J., Jr., John Hammond and A. S. Parker. 1942. Hormonal augmentation of fertility in sheep. 1. Induction of ovulation, superovulation and heat in sheep. J. Agr. Sci. 32:308.

Hart, D. S. 1950. Photoperiodocity in Suffolk sheep. J. Agr. Sci. 40:143.

Hunter, G. L., G. P. Bishop and D. L. Brown. 1958. The induction of coincident superovulation and oestrus in the anoestrous ewe. J. Agr. Sci. 51:129.

McKenzie, Fred F. and R. W. Phillips. 1933. The effect of temperature and diet on the onset of the breeding season (estrus) in sheep. Mo. Agr. Exp. Sta. Bul. 328.

Robinson, T. J. 1958. Studies in controlled artificial insemination of Merino sheep. Australian J. Agr. Res. 9:693.

Sykes, J. F. and C. L. Cole. 1944. Modification of mating season in sheep by light treatment. Mich. Agr. Exp. Sta. Quart. Bul. 26:4.

Vander Noot, George W., Ralph P. Reece and William C. Skelley. 1949. Influence of estrogen alone and in conjunction with pregnant mare serum in anestrous ewes. J. Animal Sci. 8:583.

Watson, R. H. and H. M. Radford. 1955. A note on the hours of daylight associated with the seasonal increase in sexual activity in Merino ewes. Australian Vet. J. 31:31.

Williams, S. M., U. S. Garrigus, H. W. Norton and A. V. Nalbandov. 1956. Variations in the length of estrus cycles and the breeding season in ewes. J. Animal Sci. 15:984.

Yeates, N. T. M. 1949. The breeding season of the sheep with particular reference to its modification by artificial means using light. J. Agr. Sci. 39:1.

RELATIONSHIPS AMONG LIVE AND CARCASS CHARACTERISTICS OF SELECTED SLAUGHTER STEERS [1]

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Kansas Agricultural Experiment Station, Manhattan

ONE of the major problems facing the beef cattle industry is to devise a more accurate method for determining the amount of muscle and fat and marbling in the live animal. Marbling, as set forth by the present U.S.D.A. grades, plays an important part in determining carcass grade, and carcass grade largely determines price per pound. Dunn (1960), working with 48 Hereford steers, found a correlation of 0.97 between marbling and carcass grade.

The present study is an attempt to evaluate the association of live animal measurements and scores with measures of carcass merit.

Materials and Methods

The animals used were shown in the on-foot carcass show at the 1956–57–58 International Livestock Expositions—674 steers representing Angus, Hereford, and Shorthorn breeds, ranging from 800 to approximately 1300 lb. and 12 to 22 months old. The cattle were shown by breed and were divided into three classes: junior yearling, calved between January 1 and April 30 the previous year (minimum weight, 1025 lb.); summer yearling, calved between May 1 and August 31 the previous year (minimum weight 900 lb.); and senior calf, calved between September 1 and December 31 the previous year (minimum weight, 800 lb.) The cattle were judged on foot, slaughtered, and judged in the carcass by the same committee of three men. Live weight, cold carcass weight (48 hours in cooler) and dressing percent were obtained on each steer. A show identification number was maintained on each animal throughout the on-foot and carcass judging, but was hidden during the carcass judging to prevent animal and breed identification.

While the cattle were in the squeeze chute to be mouthed for proper age classification, two head measurements were taken in inches: eye-to-eye measurements by placing a sliding venier caliper over the anterior dorsal portion of the eyes and width of muzzle by placing the sliding calipers over the muzzle just posterior to the nostrils and at the widest point. A flexible steel tape was used to measure the circumference of the round and the cannon bone in centimeters. The cannon bone was measured midway between the knee and the pastern joint on the left front leg. One end of an unstretchable cord was placed at the point of the left pin bone (*tuber ischii*) and was run under the rear flank, between the hind legs, and up over the twist and rear portion of the round to the point of origin (left pin bone). The cord was then measured with a steel tape to determine the circumference in centimeters.

While the steers were being shown, a committee of two scored them on muscling as follows: very heavy muscled, 6; heavy muscled, 5; moderately heavy muscled, 4; medium muscled, 3; slightly light muscled, 2; and light muscled, 1. The main parts of the body considered in scoring were rib, back, loin, rump, rounds, and forearm. The steers were not handled during the scoring in 1957 but were handled in 1958, because it was thought the winter hair coat made the visual score somewhat unrealistic. The cattle were handled over the ribs, top line, edge of the top, and rounds. Muscling score, eye-to-eye width, muzzle width and circumference of round were not obtained in 1956.

The left or open side of each carcass was ribbed between the 12th and 13th rib, and a tracing of the *longissimus dorsi* muscle and fat cover at the twelfth rib was made using 9 x 12 aquabee acetate sheeting. From this tracing the area of eye muscle and fat thickness were determined with aid of a ruler and

[1] Contribution No. 243, Department of Animal Husbandry, and No. 55, Department of Statistics.
[2] Department of Animal Husbandry.
[3] Presently with U.S. Air Force.
[4] Department of Statistics.
[5] Presently with the U.S. Army.
[6] The authors thank R. W. Bray, University of Wisconsin, E. A. Kline, Iowa State University, and Kenneth Fulk, Secretary of the American Shorthorn Association, for their valuable assistance in collecting the data for this study. The authors also express appreciation to the International Livestock Exposition and Swift and Armour Packing Companies for their cooperation in making possible the facilities to obtain the data.

planimeter. Area of eye muscle is given in square inches, and fat thickness in inches. A marbling score was made on each carcass according to standards set by the United States Department of Agriculture. Marbling score was the highest for rib eyes, with the most marbling and lowest for rib eyes with the least marbling.

Results and Discussion

The present system of grading slaughter cattle on foot is subject to considerable error on individual animals and does not consider the amount of muscling, the excessive thickness of outside fat cover, or the proportion of edible lean meat. Slaughter grade is determined largely by conformation, finish, and quality. These factors plus dressing percent are used to determine the value of an animal. Quality is responsible, to a large extent, for the error between live animal evaluation and carcass evaluation, because live animal characteristics, other than finish, now used as indicators of quality are not associated with quality in the carcass. Wheat and Holland (1960), working with 688 cattle, found a correlation of 0.22 between live grade with carcass grade after ribbing and 0.89 between marbling and carcass grade. They found a high correlation (0.56) between live grade and carcass conformation.

The amount of bone desirable in beef cattle is not well established. McMeekan (1950) pointed out that heavier bone is associated with more muscle in the body. Packers have indicated a desire for light bone as it is believed to be associated with greater yield. The composition of beef carcasses varies considerably in proportion of muscle to fat and bone even among cattle of similar type, weight, grade, and age according to studies made by Mackintosh (unpublished data, 1959).

The 674 steers in this study represented a special group since they had been selected for the on-hoof carcass class at the International Livestock Exposition. Strictly speaking, any inference made from this study is applicable only to animals similarly selected, but the findings may give some insight into the relative importance of certain measurements in the evaluation of beef steers in general.

This sample of steers may be thought of as one from a truncated population. Since only the cattle of higher grades are represented in the sample, selection has certainly been performed with respect to grade. Consequently selection was also made on all of those characteristics related to grade. The size of the standard deviations relative to the means (table 1) gives some indication of the extent of the truncation. For most characteristics, the coefficient of variation $\left(\frac{s}{\bar{x}}\right)$ is quite small. The means of the various measurements for different years are shown in table 1. They are very similar in the 2 years except for circumference of round which was 16 cm. greater in 1958 than in 1957. This difference may have been caused by different persons making the measurements. The repeatability of this measurement is not as high as that for a skeletal measurement because string tension and position of string over the muscles as well as leg position of the animal affect accuracy.

The simple correlations of live animal measurements and the various carcass measurements with live weight were significantly positive in all instances but two (table 1). The difference in sign between years for the two correlaton coefficients between live weight and muscling score may be explained by the fact that the muscling scores were assigned

TABLE 1. THE MEANS AND STANDARD DEVIATIONS OF THE STEER MEASUREMENTS AND THEIR CORRELATION COEFFICIENTS (r) WITH LIVE WEIGHT

Measurement	Year	Mean	Standard deviation	r[a]
Live weight	1956	1043	102.7	....
	1957	1023	108.1	....
	1958	1018	94.9	....
Muscling score	1957	4.08	0.84	0.13
	1958	3.55	1.42	—.07
Eye to eye (in.)	1957	8.61	0.34	0.55
	1958	8.68	0.45	0.36
Width of muzzle (in.)	1957	5.28	0.23	0.37
	1958	5.39	0.29	0.33
Circumference of round (cm.)	1957	134.75	6.66	0.73
	1958	150.70	7.43	0.58
Circumference of cannon (cm.)	1956	19.40	1.37	0.38
	1957	19.59	1.23	0.55
	1958	19.36	1.22	0.46
Dressing percent	1956	64.24	1.68	0.39
	1957	64.24	2.10	0.26
	1958	64.27	2.02	0.20
Marbling score	1956	8.60	0.93	0.08
	1957	8.87	1.04	0.11
	1958	8.52	1.04	0.02
Area of loin (sq. in.)	1956	11.38	1.32	0.33
	1957	11.58	1.36	0.36
	1958	11.64	1.21	0.28
Fat cover (in.)	1956	1.02	0.27	0.49
	1957	1.14	0.33	0.29
	1958	1.12	0.30	0.37

[a] r=0.13 for p=.05.
r=0.18 for p=.01.

TABLE 2. THE PARTIAL CORRELATION COEFFICIENTS AMONG STEER MEASUREMENTS WITH LIVE WEIGHT HELD CONSTANT

Measurement	Year	E.E.	W.M.	C.R.	C.C.	D.P.	M.S.	A.L.	F.C.	Part. corr. for P=.05
Muscling score	1957	—.07	—.19	0.13	—.10	0.30	0.09	0.10	0.01	0.12
	1958	—.09	—.04	0.01	—.04	0.13	0.10	0.12	0.03	0.12
	Pooled	—.08	—.08	0.07	—.07	0.21	0.10	0.11	0.02	0.09
Eye to eye (E.E.)	1957	....	0.33	0.13	0.30	—.24	—.05	0.04	—.16	0.12
	1958	....	0.24	0.12	0.28	—.15	—.00	0.02	—.06	0.12
	Pooled	....	0.28	0.12	0.29	—.20	—.02	0.03	—.11	0.09
Width of muzzle (W.M.)	1957	....	....	0.19	0.36	—.26	—.17	0.05	—.18	0.12
	1958	....	....	0.19	0.46	—.25	—.13	0.11	—.28	0.12
	Pooled	....	....	0.19	0.41	—.26	—.15	0.08	—.23	0.09
Circum. of round (C.R.)	1957	....	....	....	0.39	—.02	—.23	0.18	—.23	0.12
	1958	....	....	....	0.21	—.03	—.12	0.14	—.15	0.12
	Pooled	....	....	....	0.30	—.03	—.17	0.16	—.19	0.09
Circum. of cannon (C.C.)	1956	....	....	....	....	—.19	—.28	0.18	—.20	0.16
	1957	....	....	....	....	—.31	—.34	0.02	—.33	0.12
	1958	....	....	....	....	—.40	—.32	0.21	—.42	0.12
	Pooled	....	....	....	....	—.32	—.32	0.13	—.34	0.08
Dressing per cent (D.P.)	1956	....	....	....	....	....	0.21	0.04	0.30	0.16
	1957	....	....	....	....	....	0.21	0.23	0.30	0.12
	1958	....	....	....	....	....	0.36	0.11	0.48	0.12
	Pooled	....	....	....	....	....	0.27	0.14	0.37	0.08
Marbling score (M.S.)	1956	....	....	....	....	....	....	—.07	0.19	0.16
	1957	....	....	....	....	....	....	—.04	0.23	0.12
	1958	....	....	....	....	....	....	—.04	0.24	0.12
	Pooled	....	....	....	....	....	....	—.01	0.23	0.08
Area of loin (A.L.)	1956	....	....	....	....	....	....	....	—.43	0.16
	1957	....	....	....	....	....	....	....	—.19	0.12
	1958	....	....	....	....	....	....	....	—.26	0.12
	Pooled	....	....	....	....	....	....	....	—.27	0.08

by different people in the two years, and the steers were handled while scoring in 1958 and were not handled in 1957. The visual muscle scores made in 1957 were less accurate in predicting muscling (as measured by loin eye area, table 2) because the long winter hair coat can be misleading to the scorer.

Marbling score was not significantly correlated with live weight which indicates marbling is essentially independent of weight in this study. Since the majority of the correlation coefficients involving live weight were significant, it was decided to hold weight constant through the use of partial correlation.

The partial correlation coefficients among all pairs of measurements, independent of live weight, were computed for each year. All of the partial correlation coefficients between a given pair of characteristics were considered as estimates of the same parameter. Since any difference among the estimates could be attributed only to the chance variation inherent in studies such as this, the coefficients were not tested for heterogeneity, but directly pooled as described by Fisher (1954). These partial correlation coefficients are given in table 2.

The pooled partial correlations of muscling score with dressing percent and area of loin eye are positive and significant at the 0.05 level. Therefore, steers scored as heavy muscled, tended to dress higher and had larger eye muscles, but the correlation coefficients, even though significant, were not large enough to be of much value in prediction. Eye-to-eye measurements show a significant positive correlation with width of muzzle, circumference of round and circumference of cannon, but were significantly negatively correlated with dressing percent and fat cover at the 12th rib. Cattle that were wider between the eyes tended to have lower dressing percent. This agrees with Lush (1932). Width of muzzle had essentially the same correlations with the above traits as did eye-to-eye measurement but was more highly correlated with circumference of cannon.

Circumference of round was shown to have a significant positive correlation with circumference of cannon and area of loin eye, but was negatively correlated with marbling score and fat cover at the twelfth rib. Circumference of cannon was significantly negatively correlated with dressing percent, marbling score and fat cover, and was positively correlated with area of eye muscle (table 2). Cattle having large cannon circumference have larger loin eyes, less fat at the twelfth rib and lower dressing percents. These results agree with those of McMeekan (1950). His

studies indicated fine-boned animals of the various classes of livestock yield a smaller percent of lean meat and a larger proportion of fat than heavier boned animals of the same weight.

Dressing percent was positively correlated with marbling score, fat cover, and area of loin eye. This is reasonable as finish is an important factor in determining dressing percent, and is partially responsible for marbling (Kays, 1958). Marbling score is significantly correlated with fat cover. A significant negative correlation was found for area of loin eye with fat cover at the 12th rib. This indicates that heavily muscled steers usually have less fat, and certainly this is desirable in meat animal production if present consumer demands are met.

The majority of the pooled partial correlation coefficients, in table 2, are significant at the 0.05 level, but the magnitude of the coefficients seem to indicate little immediate usefulness. The largest pooled coefficient between a measurement on the live animal and a carcass characteristic is between circumference of the cannon and fat cover at the 12th rib ($r = -.34$). Since the square of the correlation coefficient gives the reduction in variability one obtains through knowledge of a related variable, this indicates that knowing the circumference of the cannon improves the efficiency of an estimate of the fat cover by only slightly more than 10%. In a population not subjected to selection, this is only a minor improvement in efficiency, but animals tested were from a population in which the variability already had been reduced through truncation. In addition, if one assumes the underlying density function to be that of a multivariate normal population, the truncation has reduced the size of the correlation between any two variables measured in the segment of the population being sampled.

No inference can be made beyond the type of steers represented in this study. For broader inference, a random sample of steers representing a large geographic area and the various types of feeding programs needs to be taken and studied. It is impossible to predict the magnitude of the correlation coefficients to be obtained from such a comprehensive study. However, the present study should give some idea of measurements which would be useful in such an undertaking, for the relative importance of the various relationships are likely to remain the same. Those coefficients which are statistically significant, though small, under the conditions of reduced variation should remain significant when the whole population is represented in the sample. With the greater variance and covariance in the entire population, these coefficients could become large enough to be of practical importance in predicting some carcass traits of a live animal.

Summary

In this study of 674 steers at the International Livestock Exposition in 1956–57–58 no live animal measurements were significantly correlated with marbling in the beef carcass. The following live animal measurements were significantly negatively correlated with fat cover at the 12th rib: width between the eyes, width of muzzle, circumference of round and circumference of cannon. This indicates that broad-headed, heavy-boned cattle with large rounds are desirable as such animals tend to have less fat and more lean.

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Literature Cited

Dunn, N. K. 1960. Relationships of loin eye area and other beef carcass characteristics with trimmed wholesale cuts and fat trim. M.S. Thesis. Kansas State University, Manhattan, Kansas.

Fisher, R. A. 1954. Statistical Methods for Research Workers. (12th ed.) Oliver and Boyd, Edinburgh.

Kays, J. M. 1958. Basic Animal Husbandry. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

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	Pooled	....	....	....	....	....	....	....	—.27	0.08

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EFFECT OF INBREEDING AND SELECTION ON PERFORMANCE CHARACTERISTICS OF BEEF CATTLE[1]

G. I. ALEXANDER AND RALPH BOGART
Oregon Agricultural Experiment Station, Corvallis

INBREEDING occurs in a one-or two-sire herd closed to outside breeding stock. Inbreeding experiments have shown generally that the closer the character is related to fitness, the more it is subject to inbreeding depression (Lerner, 1958). von Krosigk and Lush (1958), by the use of intrasire regressions of production on inbreeding, were able to determine the effect of inbreeding on production with the effect of other variables minimized. They found that inbreeding caused an appreciable decline in milk and butter-fat production and that all of this decline could not be attributed to a decrease in general size. Fine and Winters (1953) record that, of two inbred lines of swine selected for performance traits, one declined in performance while the other showed a slight increase in merit with time. They used time trends in performance as their indices of improvement.

It is reasonable to expect that a useful measure of potential improvement through selection may be to observe the effects of inbreeding on a number of traits which are subjected to selection either directly or indirectly. By this means it may be possible to determine whether there has been a loss in phenotypic merit due to inbreeding overpowering selection or whether inbreeding depression has been offset by the selection method practiced.

Materials and Methods

The beef cattle under study were bred at the Oregon Agricultural Experiment Station, Corvallis. Two breeds were represented. The Herefords consisted of three closed lines. The Lionheart line of cattle has been closed to any outside introductions since 1950. The Prince and David lines originated from the same parent stock but different from the Lionheart line. No outside bulls have been used for breeding in either the Prince or the David line since 1948, but prior to 1950 some of the cows were used in both lines. Since 1950, these two lines have been maintained as separate entities. The Aberdeen Angus cattle have been maintained as a closed line since 1950 with the exception of one bull introduced and used in 1953 and 1954.

The feeding and management of the calves prior to weaning and the feed-test procedures have been described by Dahmen and Bogart (1952), Nelms *et al.* (1953), Price *et al.* (1959), and MacDonald *et al.* (1956).

Selection of the replacement stock was based on an index composed of suckling gains, gains during the feed test, feed consumption per unit gain and score for type and conformation. The index for each animal was constructed as follows:

$$\frac{S-\bar{S}}{s_S}+\frac{F-\bar{F}}{s_F}-\frac{E-\bar{E}}{s_E}+\frac{G-\bar{G}}{s_G}$$

where: S=suckling gain.
F=feed test gain.
E=feed consumption per unit of gain.
G=score.
$\bar{S}$, $\bar{F}$, $\bar{E}$, $\bar{G}$=within-line, within-year, means for respective traits.
s=standard deviation.

The index was constructed on a within-line, within-year basis. Two bulls were used in each line, each year. These were usually bulls which had been performance-tested the previous year. However, some degree of flexibility was retained so that if a bull of outstanding performance was obtained, he could be used for two years instead of one. The Hereford lines consisted of approximately 15 cows in each line while the Angus line contained approximately 20 cows.

The data analysed in this study came from 280 calves which were born in the period from 1952–57. The birth weights, rate of gain while suckling, age at 500 lb. body weight, rate of

[1] This study was conducted in co-operation with the Agricultural Research Service, U.S. Department of Agriculture, and State Experiment Stations under Western Regional Research Project W-1 on Beef Cattle Breeding Research. Technical Paper No. 1377, Oregon Agricultural Experiment Station, Corvallis, Oregon.

TABLE 1. DISTRIBUTION OF CALVES BY INBREEDING

Line and sex	Coefficient of inbreeding, %					No. of animals
	0	0–10	10–20	20–30	30	
Lionheart:						
Males	1	11	13	4	0	29
Females	1	9	11	3	0	24
Both	2	20	24	7	0	53
Prince:						
Males	4	13	21	2	0	40
Females	1	10	19	3	0	33
Both	5	23	40	5	0	73
David:						
Males	0	2	22	8	2	34
Females	3	3	9	10	0	25
Both	3	5	31	18	2	59
Angus:						
Males	16	9	7	0	1	33
Females	23	18	18	3	0	62
Both	39	27	25	3	1	95
All animals:	49	75	120	33	3	280

gain on feed test, feed consumption per 100 lb. gain, and age at 800 lb. body weight were considered for each calf.

The factors which have been examined are: (a) line, (b) year, (c) sex, and (d) amount of inbreeding of calf, calculated according to the method of Wright (1922). Examination of the data disclosed some confounding between these factors. There was a slightly faster rate of inbreeding in the David line than in other lines (table 1). This was not considered to be of major consequence. Year and degree of inbreeding were confounded as in each succeeding year there was a higher degree of inbreeding. The model used (Model A) was:

$$Y_{ijkl}=M+S_i+L_j+Y_k+Bx_{jkl}+e_{ijkl}$$

where: Y_{ijkl}=the observation on the l^{th} calf in the k^{th} year, of the j^{th} line and i^{th} sex, with an inbreeding of x_{jkl}

M=the overall effect.

S_i=the added effect of the i^{th} sex.

L_j=the added effect of the j^{th} line.

Y_k=the added effect of the k^{th} year.

B=a constant proportional to the linear relationship between the degree of inbreeding and the change in the characteristic under consideration.

x_{jkl}=inbreeding coefficient for the jkl^{th} calf.

e_{ijkl}=random error

Two supplementary models were used: (1) the effect of year was not considered, and (2) the effect of inbreeding was not considered. The models were used omitting first the inbreeding and then the year terms and the differences between these regression sums of squares due first to year and then to inbreeding alone were determined.

In order to estimate any effect of inbreeding of dam on the performance of its offspring, a similar model (Model B) was used in which the effects of: (a) line, (b) sex, (c) amount of inbreeding of calf, and (d) amount of inbreeding of dam were examined. A supplementary model in which the inbreeding of the dam was not considered was used and the difference between the two regression mean squares was considered to estimate the effect of inbreeding of dam which would also incorporate some of the effects of selection pressure. For convenience, the year effect was not considered in this model. An examination of the constants estimated (table 3), indicates that there is little difference between the results by using the two models.

Results and Discussion

This study has some of the same weaknesses as others that have been made in which attempts to assess the effects of inbreeding are difficult because of limited numbers involved and the confounding of some of the material. In most research with inbreeding of farm animals one finds a confounding of inbreeding effects with selection. Also, one generally has inbred parents producing offspring with a greater inbreeding than young produced by non-inbred animals. In spite of these difficulties, some interesting indications are evident from the data in this and other studies that have been made on effects of inbreeding.

TABLE 2. ANALYSIS OF VARIANCE OF BIRTH WEIGHT, SUCKLING GAINS, AGE AT 500 AND 800 LB. AND FEED ECONOMY

		Model A					
		Mean square					
Source of variation	d.f.	Birth weight	Suckling gain	Age at 500 lb.	Rate of gain	Feed economy	Age at 800 lb.
Effect of sex, line, year and inbreeding	10	1796**	1.05**	17407**	4.51**	688860**	48994**
Reduction due to inbreeding of calf	1	62	1.32**	15356**	0.08	695	12040**
Reduction due to year	5	1560**	1.01**	20104**	2.22**	365655**	44697**
Error	269	26	0.06	512	0.05	4089	543
		Model B					
		Mean square					
Source of variation	d.f.	Birth weight	Suckling gain	Age at 500 lb.	Rate of gain	Feed economy	Age at 800 lb.
Effect of sex, line, inbreeding of dam	6	1994**	1.09**	15617**	6.60**	964396**	52725**
Reduction due to inbreeding of dam	1	7	0.04	2740	1.12**	37191	896
Error	273	54	0.08	863	0.08	10589	1350

** Significant at the 1% level of probability.

The interpretations that have been placed on the results obtained need verification by other research before they can be accepted as facts even though all appear to be sound biological interpretations.

The estimated inbreeding effect is actually that remaining after selection so that it is really a measure of the effectiveness of selection in counter-acting any depression there might otherwise have been due to inbreeding. Alternately, it may indicate that there is no inbreeding effect on the particular character.

When the effects of year and inbreeding are separated in the analysis it is apparent that in every case there is a significant effect of years (table 2). However, when the effects of inbreeding are considered they appear to fall into two distinct classes, those where there is no significant effect in excess of the positive effects of selection, and those in which there is an effect significant at the one percent level of probability. Birth weight, rate of gain on test, and feed consumption per unit of gain did not appear to be affected by inbreeding in excess of the selection effect, whereas suckling gain and age at 500 and at 800 lb. body weight were significantly affected. If the constants associated with inbreeding are expressed as a percent of the standard deviation estimated from the error mean square (table 2), two orders of effect are shown. Birth weight was depressed by 1.5%, rate of gain by 1.2% and feed consumption per unit of gain by 0.5% of their respective standard deviations. None of these traits were significantly different for inbreds as contrasted to those not inbred. By contrast, suckling gain was depressed by 4.4%, age at 500 lb. was increased by 5.3%, and age at 800 lb. by 4.5% of the standard deviations, all of which were significantly different from calves with no inbreeding ($P<.01$).

An explanation for these groupings of effects may be found in table 4 where the correlation between birth weight and rate of gain is shown to be 0.46 and that between birth weight and feed consumption per unit of gain, —.53. Suckling gain was highly and negatively correlated with age at 500 lb. body weight and age at 800 lb. body weight. It is assumed that most of the environmental variations were removed in the analysis and that these correlations reflect genetic associations.

An explanation for the absence of a depressing effect of inbreeding on birth weight may be postulated on the basis of heritabilities reported by Shelby *et al.* (1955). They found high heritabilities for birth weight (0.72) and rate of gain (0.60) and Knapp and Nordskog (1946) report heritabilities of efficiency at between 0.48 and 0.75. Since the heritability of weaning weight, which is similar to age at 500 lb. in this study, was 0.23, it is the highly heritable traits where the inbreeding depression was not in excess of the selection effect. The high correlations (table 4) between birth weight, for which there was no selection, and rate of gain and feed economy, for which selection was applied, may suggest that selection

for rate of gain and feed economy has tended to prevent a decline in birth weight that might have resulted from inbreeding.

Suckling gains showed a significant degree of depression with inbreeding. This would indicate that inbreeding depression was not compensated for by the effectiveness of selection for this trait.

Age at 500 lb. body weight is basically an inverse expression of suckling gains. Age at 800 lb. body weight is an inverse expression of both suckling and feed-test gains. However, suckling gains influence age at 800 lb. body weight to a greater extent than feed-test gains. Thus, it appears that inbreeding increased both age at 500 lb. and age at 800 lb. body weights primarily because of its depressing effect on suckling gains.

A study of the records shows that, for each of the three traits (suckling gains, feed-test gains, and feed efficiency), very little selection of females was practiced. However, there was considerable selection of bulls for each of these traits. There was an average of 0.15 lb. (8.2%) higher suckling gains, 0.23 lb. (8.5%) higher feed-test gain, and 56 lb. (8.1%) less feed per 100 lb. gain for the selected bulls over the entire population of bulls from which they were selected. This shows that approximately equal selection pressures were applied to the three traits. In spite of this, suckling gains showed a significant degree of depression with inbreeding while there was no evidence of depression in feed-test gain or in feed economy (tables 2 and 3). Apparently either the additive genetic effects of suckling gains are lower than for the other traits, or the inbreeding effect is greater, or both.

Since ages at 500 lb. and at 800 lb. body weight reflect relative growth rates during the suckling period entirely or to a greater extent than during the feed test, these two traits would be expected to show the same depressing effect of inbreeding as do suckling gains. Thus, inbreeding effect is greater than selection effect for ages at 500 and 800 lb. body weights.

The effect of inbreeding of the dam on the performance of her calf was significant only for the feed-test gains; the more highly inbred cows produced calves that gained more rapidly at this time (tables 2 and 3). The more highly

TABLE 3. EFFECTS OF LINE, SEX, YEAR AND INBREEDING ON THE PERFORMANCE CHARACTERISTICS OF THE CALVES

Model A	Estimates of effects on:					
Effect	Birth weight	Suckling gain	Age at 500 lb.	Rate of gain	Feed economy	Age at 800 lb.
Overall effect (Angus females) for year 1957	57.95	1.82	243.18	1.90	1009.99	404.72
Sex[a]	4.40	0.16	−28.34	0.65	−236.43	−64.61
Lionheart line	14.79	−.05	2.59	0.32	−94.09	−10.48
Prince line	13.37	−.14	8.85	0.30	−168.87	−8.41
David line	8.18	−.16	17.54	0.37	−113.97	2.99
Year 1952	1.47	0.12	1.98	0.04	−69.33	−4.54
1953	0.08	−.01	−1.13	−.16	−9.01	4.45
1954	−1.26	0.01	1.20	−.02	−1.52	2.89
1955	0.26	0.11	−6.07	−.12	114.04	−1.45
1956	−.54	0.07	−3.82	0.03	33.83	−2.04
Inbreeding[b]	−.07	−.01	1.19	−.003	0.32	1.06

Model B	Estimates of effects on:					
Effect	Birth weight	Suckling gain	Age at 500 lb.	Rate of gain	Feed economy	Age at 800 lb.
Overall effect (Angus females)	58.04	1.88	242.43	1.87	1016.16	404.38
Sex	4.25	0.16	−29.57	0.63	−229.23	−64.94
Lionheart line	13.94	−.09	0.90	0.28	−115.24	−14.24
Prince line	13.38	−.16	9.81	0.28	−174.50	−6.82
David line	7.28	−.19	15.09	0.30	−138.10	−.51
Inbreeding of calf[b]	−.09	−.01	0.93	−.01	1.11	0.90
Inbreeding of dam[b]	0.03	−.00	0.51	0.01	0.88	0.28

[a] Males.
[b] The effect upon the traits under consideration for each 1% inbreeding.

inbred cows were sired by bulls in which selection has been practiced for a greater number of generations and were bred to more highly selected bulls. These factors probably account for the positive relationship between inbreeding of dam and feed-test gains of the calves.

Since inbreeding of the dam was positively associated with feed-test gains of their calves, one might feel that selection resulted in a greater frequency of genes for rapid growth. This could account for the failure of inbreeding of the calf to depress its post-weaning gains.

The depressing effect of inbreeding on suckling gains of the calf would indicate that selection has not been effective in increasing the frequency of genes for growth during this period. It also suggests that the suckling period and the post-weaning period are, in part, under different genetic control. The depressing effect of inbreeding on suckling gains while that of age at 800 lb. on suckling gains with the effect of birth weight removed was —95.59. Thus, this supports the information yielded by the simple correlations that birth weight may have less influence on age at 800 lb. than the suckling gains. There was no significant association between age at 800 lb. and the inbreeding of the dam.

In general, it would appear that either selection has tended to offset a possible depression due to inbreeding on rate of post-weaning gain and feed consumption per unit of gain or these traits are not depressed by inbreeding. No significant inbreeding depression was observed in birth weight over the range of inbreeding studied.

Summary

The combined effects of selection and inbreeding of calf and of dam were studied using 280 calves from four inbred lines of Hereford and Angus cattle. No evidence of an effect of inbreeding of the calf on birth weight, post weaning rate of gains or feed economy during performance test was found. The failure of inbreeding to depress feed-test criteria was considered to be due to the compensation of selection for the expected inbreeding depression. Significant effects due to inbreeding were found for suckling gains, age at 500 lb. body weight and age at 800 lb. body weight. There was a significant positive association between inbreeding of dam and rate of gain of her calf indicating the effectiveness of selection for rate of gain.

TABLE 4. SIMPLE CORRELATIONS (r) BETWEEN PERFORMANCE DATA FOR THE CALVES[a]

Trait	Suckling gain	Age at 500 lb.	Rate of gain	Feed economy	Age at 800 lb.
Birth weight	0.11	—.31	0.46	—.33	—.49
Suckling gain	....	—.84	0	—.08	—.61
Age at 500 lb.	....	...	—.18	0.26	0.81
Rate of gain	....	...	....	—.86	—.64
Feed economy	....	...	....	....	0.66

[a] r=0.14 for P=.05.
r=0.18 for P=.01.

cannot be attributed to a reduction in milk supply of the dam because there was no significant depression in suckling gains associated with inbreeding of the dam (table 2).

The lack of significance of the degree of inbreeding depression on rate of gain and feed economy indicate that either selection has been effective in offsetting inbreeding depression or that these traits are not subject to such inbreeding depression.

As can be readily seen, age at 800 lb. is related to all the other characteristics. This is confirmed by the relatively high correlations, recorded in table 4, between age at 800 lb. body weight and the other performance characteristics. Because the increase in age at 800 lb. body weight due to inbreeding seems to be more closely associated with that of suckling gains and age at 500 lb. body weight, it would seem desirable to determine the separate effects of birth weight and suckling gain on age at 800 lb. The partial regression coefficient of age at 800 lb. body weight on birth weight with suckling gains held constant was 0.33

Literature Cited

Dahmen, Jerome J. and Ralph Bogart. 1952. Some factors affecting rate and economy of gains in beef cattle. Ore. Agr. Exp. Sta. Tech. Bul. 26.

Fine, N. C. and L. M. Winters. 1953. Selection for an increase in growth rate and market score in two inbred lines of swine. J. Animal Sci. 12:251.

Knapp, Bradford, Jr. and A. W. Nordskog. 1946.

Heritability of growth and efficiency in beef cattle. J. Animal Sci. 5:62.

Lerner, I. M. 1958. The Genetic Basis of Selection. John Wiley and Sons, New York.

MacDonald, M. A., Hugo Krueger and Ralph Bogart. 1956. Rate and efficiency of gains in beef cattle. IV. Blood hemoglobin, glucose, urea, amino acid nitrogen, creatinine, and uric acid of growing Hereford and Angus calves. Ore. Agr. Exp. Sta. Tech. Bul. 36.

Nelms, George E., C. M. Williams and Ralph Bogart. 1953. A completely pelleted ration for performance testing beef cattle. Proc. West Sect. Am. Soc. An. Prod. 4:1.

Price, D. A., George E. Nelms and Ralph Bogart. 1955. The relationships of some digestion coefficients to rate and efficiency of gains in growing beef cattle. Proc. West. Sect. Am. Soc. An. Prod. 6:217.

Shelby, C. E., R. T. Clark and R. R. Woodward. 1955. The heritability of some economic characteristics of beef cattle. J. Animal Sci. 14:372.

von Krosigk, C. M. and J. L. Lush. 1958. Effect of inbreeding on production in Holsteins. J. Dairy Sci. 41:105.

Wright, Sewall. 1922. Coefficients of inbreeding and relationship. Am. Nat. 56:330.

COMPARISON OF NATURAL MATING WITH ARTIFICIAL INSEMINATION AND INFLUENCE OF SEMEN VOLUME AND SPERM NUMBERS ON CONCEPTION, EMBRYO SURVIVAL AND LITTER SIZE IN SOWS [1, 2]

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NUMEROUS reports suggest that artificial insemination in swine is reasonably successful when large volumes of semen and large numbers of spermatozoa are used. However, the relative success of artificial insemination when compared with natural mating has not been established. Hancock (1958) found conception rate in artificially inseminated sows to be inferior to that obtained with natural mating. His results were based on evaluating ova at 3 days of gestation as were the results of Wiggins *et al.* (1951) whose data suggested that a volume greater than 50 ml. was required for sows. Self (1959) reported a conception rate of 92.1% based on 3-day fertilization rates and 47.6% at the 25th day of gestation. This suggests that considerable error may be involved when conception rates are determined by examining cleaved ova at the third day of gestation. Stratman and Self (1960), using 25-day data, found no improvement in conception rates when gilts were inseminated with more than 2.5×10^9 spermatozoa in 50 ml. of semen. However, reducing the total volume used per insemination from 50 ml. to 20 or 10 ml. lowered conception rate regardless of the number of spermatozoa used.

The purpose of this study was to obtain additional information on the total volume of semen and spermatozoan numbers required per insemination in sows.

Materials and Methods

A dummy sow and artificial vagina were used to obtain semen from three boars (two yearling Hampshires and one 2-year-old Duroc). The boars were self-fed a ration calculated to contain 16.2% crude protein, 68.0% TDN, and 12.3% fiber and containing trace mineralized salt, an antibiotic and zinc sulfate.

The ejaculate was fractionated manually through visual observation during collection into two portions, i.e., one containing the translucent pre-sperm and post-sperm fractions and one containing the more opaque sperm-rich fraction. Immediately after collection and volume measurement, the two portions were strained separately through 36 x 44 mesh cheese cloth, volume was again recorded, and the spermatozoa of the sperm-rich fraction were evaluated for type of and percent of motility (Stratman *et al.*, 1958). The portion containing pre-sperm and post-sperm fractions was discarded. The total volume of the combined pre-sperm and post-sperm fractions ranged from 22.0 to 240.0 ml. with a mean of 115.0 ml., while the strained volume ranged from 22.0 to 194.0 ml. with a mean of 87.9 ml. The total volume of sperm-rich fraction ranged from 30.0 to 130.0 ml. with a mean of 68.2 ml., while the strained volume ranged from 28.0 to 100.0 ml. with a mean of 58.8 ml. The rating for type of motility of the sperm-rich fraction ranged from 5.0 to 9.0 with a mean of 8.6, while the percent sperm that were motile ranged from 70.0 to 95.0 with a mean of 86.8.

Spermatozoa per ml. was established by using the mean of two counts with a hemocytometer. The average concentration was 896.9×10^6 per ml. of sperm-rich fraction. The amount of sperm-rich fraction necessary to supply the total number of spermatozoa for each insemination was pipetted into a graduate containing the proper amount of diluent at approximately the same temperature as the semen.

The diluent used was whole homogenized milk heated to 93° C. for 10 minutes (Thacker and Almquist, 1951). Dihydrostreptomycin

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sulfate was added at the rate of 1000 mcg. per ml.

Ninety-six sows, 1 to 3 years old and with no known breeding problems, were obtained from the Wisconsin Experiment Station swine breeding herds as they became available over a period of months. The first lot was made up of 12 Duroc and 12 Yorkshire; the second lot, 24 crossbred Duroc-Yorkshire sows; the third lot, 4 Poland China, 2 Yorkshire and 6 Chester White sows; the fourth lot, 8 Chester White and 8 Poland China sows, and the fifth lot consisted of 20 crossbred Duroc-Yorkshire sows.

Sows were maintained in concrete pens with access to an outside run. They were self-fed the same ration as consumed by the boars. A boar was used to check them for estrus at 24-hour intervals. If the sow allowed the boar to mount, she was considered to be in estrus. Copulation was not permitted.

The first, second and fifth lots were inseminated on the second post-weaning estrus (pigs weaned at 5 weeks) while the third and fourth lots had one or more estrous cycles before insemination.

Intra-cervical insemination was accomplished by using a modified plastic inseminating tube and was completed within 30 minutes from the time of collection of semen. One service was allowed for those sows mated naturally. Service appeared to be normal in all matings. All sows were bred either naturally or artificially approximately 24 hours from the time they were first detected in estrus.

As they exhibited estrus, the sows in each lot were randomly assigned to either natural mating (Group 1) or were inseminated artificially with 2.5 x 10^9 spermatozoa in 50 ml. of diluent (Group II), 2.5 x 10^9 spermatozoa in 100 ml. of diluent (Group III) or 1.25 x 10^9 spermatozoa in 100 ml. of diluent (Group IV).

Boars were rotated in a regular sequence for semen collection or natural service. The interval between collections and/or natural services varied from one day to a week depending on the frequency with which the sows came into estrus. The motility of the spermatozoa obtained from Boar C declined to approximately zero during the interim between breeding Lot III and Lot IV sows; consequently, he was removed from the experiment.

Sows were slaughtered 23 to 27 days post-breeding (25-day stage). The reproductive tracts were recovered and the embryos examined. Unless signs of degeneration were present, the embryo was considered to be alive at the time of slaughter.

Percent embryo survival is expressed as the portion of the corpora lutea represented by live embryos at the 25th day. Percent conception is expressed as the portion of sows inseminated that had one or more live embryos at slaughter. Twenty-five-day litter size is expressed as the number of live embryos at slaughter.

All percent were transformed to angles and the data analyzed by analysis of variance and by use of Duncan's (1955) multiple range test.

Results and Discussion

The ovulation rate, percent conception, percent embryo survival and litter size are shown in table 1.

TABLE 1. OVULATION RATE, CONCEPTION RATE, EMBRYO SURVIVAL AND LITTER SIZE AT 25-DAYS GESTATION BY TREATMENT GROUPS

Boar	Method of mating	No. of spermatozoa, x 10^9	Volume ml.	No. sows bred	Ovulation rate	Conception rate	Percent survival		Litter size	
					Pregnant sows		All sows	Pregnant sows	All sows	Pregnant sows
A	Natural	...	...	9	16.5	44.4	22.0	49.6	3.7	8.2
	AI	2.5	50	9	15.7	77.8	67.6	87.0	10.7	13.7
	AI	2.5	100	9	18.8	77.8	66.9	86.0	12.4	16.0
	AI	1.25	100	9	16.6	77.8	56.4	72.6	9.1	11.7
B	Natural	...	...	10	15.2	90.0	68.5	76.1	10.2	11.3
	AI	2.5	50	10	14.0	60.0	44.3	73.8	6.3	10.5
	AI	2.5	100	10	16.4	77.8[a]	56.7	72.8	9.6	12.0
	AI	1.25	100	10	14.2	60.0	41.9	69.9	5.9	9.8
C	Natural	...	...	5	19.0	20.0	4.2	21.0	0.8	4.0
	AI	2.5	50	5	14.8	100.0	64.5	64.5	9.0	9.0
	AI	2.5	100	5	14.3	60.0	44.6	74.4	6.4	10.6
	AI	1.25	100	5	18.0	40.0	35.7	89.3	6.6	16.5
All boars	Natural	...	...	24	16.9	58.3	31.6	48.9	5.8	7.8
	AI	2.5	50	24	14.8	75.0	58.8	75.1	8.5	11.1
	AI	2.5	100	24	16.5	73.9	56.1	77.7	10.0	12.9
	AI	1.25	100	24	16.3	62.5	44.7	77.3	7.2	12.7

[a] Based on nine sows, one sow was lost during slaughter.

Ovulation rates (mean = 16.1), as derived from the number of corpora lutea of pregnant sows, did not differ significantly among treatment groups.

Conception rate did not differ significantly among treatments or among boars, nor was there a significant interaction. Increasing the volume inseminated from 50 to 100 ml. had little effect on the conception rate when a total of 2.5 x 10^9 spermatozoa were used. In the 100 ml. volume reducing the number of spermatozoa from 2.5 x 10^9 to 1.25 x 10^9 reduced the rate of conception 11.4%. The 58.3% conception at 25-days post-breeding slaughter for sows mated by natural service is lower than the 83.3% obtained with 12 sows (Stratman, 1961) for first service based on farrowing data. There is no apparent explanation for the wide fluctuation of results among boars in this study when used naturally; however, since only the sperm-rich fraction was used for artificial insemination, the concentration of the constituents in the seminal fluid deposited during natural service may have been responsible for the differences in the results obtained. Boar B had a higher conception rate with natural mating, whereas Boars A and C produced better results when used for artificial insemination. The 70.4% conception at 25-days post-breeding slaughter for the artificially inseminated groups is slightly higher than the 65.5% based on farrowing data reported by Aamdal and Hogset (1957) for sows inseminated with 41 x 10^9 to 100 x 10^9 spermatozoa in 150 to 200 ml. of diluent and the 50.0% based on farrowing reported by Madden (1959) when sows were inseminated with 100 ml. of diluted semen, but lower than the 77.8% based on farrowing data obtained with 9 sows inseminated once with 50 ml. of fresh whole strained semen combined with 50 ml. of a milk diluent (Stratman, 1961). However, for these comparisons to be valid one must consider that appreciable intra-uterine mortality occurs after the 25th day of gestation (Gossett and Sorensen, 1959). Although not statistically significant, there appeared to be a tendency for conception rate to be lower in sows inseminated with 1.25 x 10^9 spermatozoa suspended in 100 ml. (62.5%) than when inseminated with 2.5 x 10^9 spermatozoa in either 50 (75.0%) or 100 ml. (73.9%).

Percent embryo survival did not differ significantly among treatments or among boars; however, a significant boar-treatment interaction ($P<0.05$) was noted. The 48.9 mean percent embryo survival for those sows pregnant from natural service is lower than the 65.4% reported by Squiers *et al* (1952), however, it is similar to that reported by Self *et al.* (1955) for gilts bred by natural service.

The pregnant sows in the three artificially inseminated groups averaged 76.7% embryo survival for all groups with only slight differences among the group means.

The mean litter size in the pregnant sows of the natural service group was 7.8 pigs compared to a mean of 12.2 pigs for all pregnant sows in the three groups bred by artificial insemination.

There appears to be little difference in the conception rate, embryo survival or litter size at the 25th day of gestation when sows were artificially inseminated with either 50 or 100 ml. of diluent containing 2.5 x 10^9 spermatozoa. Reducing the number of spermatozoa to 1.25 x 10^9 in 100 ml. of diluent lowered values for these traits a nonsignificant amount.

Summary

Ninety-six sows of mixed breeding, having exhibited one or more pre-experimental estrous cycles, were assigned randomly to four treatment groups and were bred on the second day of the experimental estrous period either by natural service or artificially with semen from one of three boars. Group I sows were bred by natural service. Group II sows were inseminated with 2.5 x 10^9 spermatozoa in 50 ml. of milk diluent containing 1000 mcg. dihydrostreptomycin sulfate per ml. Group III sows were inseminated with 2.5 x 10^9 spermatozoa in 100 ml. of diluent and Group IV sows were inseminated with 1.25 x 10^9 spermatozoa in 100 ml. of diluent. All sows were slaughtered 25-days post-breeding. The mean percent conception rate for the four groups was 58.3, 75.0, 73.9, and 62.5, respectively. The mean number of corpora lutea present in those sows pregnant was 16.9, 14.8, 16.5, and 16.3 for the four groups, respectively. The mean percent of corpora lutea represented by embryos at the 25th day of gestation for the pregnant sows was 48.9, 75.1, 77.7 and 77.3 for these four groups, respectively, while the average litter size for the pregnant sows was 7.8, 11.1, 12.9 and 12.7 pigs in the four groups, respectively. Percent conception rate, number of corpora lutea, and litter size did not differ significantly among treatments or among boars nor were there any significant interactions.

Percent embryo survival did not differ significantly among treatments or among boars, but a significant boar-treatment interaction occurred ($P<0.05$).

Literature Cited

Aamdal, J. and I. Hogset. 1957. Artificial insemination in swine. J. Am. Vet. Med. Assn. 131:59.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics 2:1.

Gossett, J. W. and A. M. Sorensen, Jr. 1959. A comparison of embryo survival in gilts slaughtered 25 versus 40 days after breeding. J. Animal Sci. 18:48.

Hancock, J. L. 1958. The fertility of natural and artificial matings in the pig. Studies on Fertility 9:146.

Madden, D. H. L. 1959. Progress in the artificial insemination of swine—some factors influencing fertility levels in its field application. Vet. Rec. 71:227.

Self, H. L. 1959. The problem of storing and inseminating boar semen. Colloquium on reproduction and artificial insemination of the pig. Annales de Zootechnie Institut National de la Recherche Agronomique, Jouy-en-Josas, France.

Self, H. L., R. H. Grummer and L. E. Casida. 1955. The effects of various sequences of full and limited feeding on the reproductive phenomena in Chester White and Poland China gilts. J. Animal Sci. 14:573.

Squiers, C. D., G. E. Dickerson and D. T. Mayer. 1952. Influence of inbreeding, age and growth rate of sows on sexual maturity, rate of ovulation, fertilization and embryonic survival. Mo. Agr. Exp. Sta. Res. Bul. 494.

Stratman, F. W. 1961. Various factors affecting artificial insemination in swine. Ph.D. Thesis. University of Wisconsin, Madison, Wisconsin.

Stratman, F. W. and H. L. Self. 1960. The effect of semen volume and number of sperm on fertility and embryo survival in artificially inseminated gilts. J. Animal Sci. 19:1081.

Stratman, F. W., H. L. Self and V. R. Smith. 1958. Fertilization rates obtained with boar semen stored for zero and twelve hours. J. Animal Sci. 17:598.

Thacker, D. L. and J. O. Almquist. 1951. Milk and milk products as diluters for bovine semen. J. Animal Sci. 10:1082.

Wiggins, E. L., R. H. Grummer and L. E. Casida. 1951. Minimal volume of semen and number of sperm for fertility in artificial insemination in swine. J. Animal Sci. 10:138.

EFFECTS OF ADDED DIETARY FAT ON FATTY ACID COMPOSITION AND CARCASS CHARACTERISTICS OF FATTENING STEERS [1, 2, 3]

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THOMAS *et al.* (1934) found no significant differences in degree of saturation, firmness and color of carcass fat from steers fed different rations containing oils of widely varying degrees of saturation. In swine, on the other hand, Ellis and Hankins (1925) found that unsaturated acids in the ration were deposited in the animals with little modification unless utilized for energy. Such findings suggested that the ruminant possesses a mechanism not available to the monogastric animal for dealing with unsaturated dietary fats. Brooker and Shorland (1950) postulated a difference in the nature of fat metabolism in the ox and sheep, as contrasted to that of the horse and rabbit. Reiser (1951) demonstrated that rumen contents were able to hydrogenate linolenic acid to linoleic acid, and proposed that rumen microorganisms served as agents of hydrogenation. Shorland *et al.* (1955) found evidence that sheep rumen contents were able to completely saturate linolenic, linoleic and oleic acids. Further evidence in support of the theory of ruminal biohydrogenation has been presented by Hoflund *et al.* (1955, 1956a, 1956b); by Reiser and Reddy (1956); and by Pfander and Verma (1957).

Materials and Methods

Cattle in Drylot. In the summer of 1956, 18 yearling steers of beef breeding, with an average initial weight of approximately 660 lb., were placed in drylot. The animals were divided into three groups of six steers. The steers were grouped according to sires and previous nutritional treatment; within these restrictions, assignment to rations was at random. The previous nutritional treatment pertained to wintering level. The steers had been wintered on silage only or silage plus corn with average daily gains of 0.66 and 1.18 lb. respectively.

In this trial, designated as Trial 1, the control ration (A) contained no added fat. Rations B and C contained, respectively, apapproximately 2.5% and 5.0% stabilized animal fat (yellow grease). The basal ration was composed of ground earn corn with shucks 1700 lb., solvent-extracted soybean oil meal (44% protein) 150 lb., cane molasses 100 lb., dehydrated alfalfa meal 50 lb., trace-mineralized salt 5 lb., feeding limestone 5 lb. and "Aurofac" (3 gm. Chlortetracycline per lb.) 3 lb. The three rations were formulated to be approximately equal in protein content, and ground corn cobs were added to Rations B and C in amounts sufficient to make the fiber content of all rations approximately equal. No attempt was made to equalize the energy contents of the rations. Each steer received 36 mg. diethylstilbestrol by ear implantation at the beginning of the trial. Mixed hay of fair quality was fed to each group in equal quantities during the course of the experiment. The concentrate portion of the rations was also fed at the same rate to all three groups of steers.

At the end of 154 days the animals were weighed, slaughtered and carcass data were obtained for each steer. Rind thickness was measured by the method of Naumann (1951). Ribs 9–10–11–12 from the right side of each animal carcass were used for study and analysis, with ribs 9–10–11 being physically separated into fat, lean and bone. The eye

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muscle was separated from the 12th rib, ground and ether extract and moisture determined. A sample of the separable rib fat from each animal was wrapped in moisture-proof paper and stored in a freezer at 0° F. for approximately 16 months until suitable techniques were developed for determining fatty acid composition.

Cattle on Pasture. After data had been obtained on the fatty acid composition of depot fat from the drylot steers in Trial 1, fat samples were analyzed from 20 steers finished on pasture. These animals were yearlings of beef breeding, weighing initially approximately 725 lb. and were part of those on an experiment here designated as Trial 2, conducted in the summer of 1957. All of the animals had been on clover-fescue pasture supplemented with grain. One-half of the steers had received ground corn free-choice with 7-10% added salt to limit intake, while the other one-half had received ground corn free-choice with 10% added animal fat (yellow grease) to limit intake. The animals had been on pasture for 131 to 184 days before slaughter. Ten of the steers (five on each type of grain mixture) had received ear implants (24 mg.) of diethylstilbestrol in the fall and again in the spring, the remaining 10 animals had received no stilbestrol. Samples of rib fat were taken from each carcass in the same manner as in Trial 1. These fat samples were stored for approximately 6 months in the freezer before analysis for fatty acid content.

Procedure for Fatty Acid Determination. The stored fat samples from the steers in Trial 1 were rendered for approximately 4 hours at 93–95° C. Fat samples from the steers in Trial 2 were rendered prior to storage. The samples of rendered fat were sealed in an atmosphere of carbon dioxide until analyzed. Each sample was then liquified by gentle heating, and approximately 1 ml. saponified for one hour under nitrogen by the method of A.O.A.C. (1955). After saponification, the material was taken up in chilled distilled water and the nonsaponifiable materials extracted with ether. The aqueous solutions of potassium soaps were made acid to congo red by the addition of 10 N HCl, and the free fatty acids extracted with ether. The ethereal solutions of fatty acids were dried with anhydrous sodium sulfate, and then methylated by means of a solution of diazomethane in ether. The diazomethane was prepared by the method of Arndt (1935).

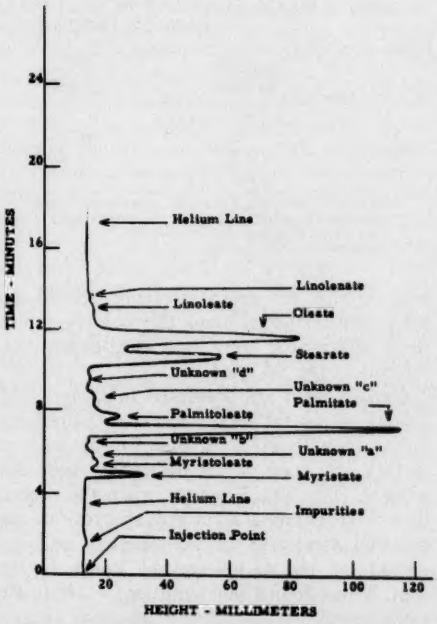

Figure 1. Gas chromatogram of methylated fatty acids from rib fat of drylot steer fed ration with approximately 5% added animal fat.

The methylated fatty acids from each fat sample were separated by gas chromatography according to the general method of Orr and Callen (1958). A representative chromatogram obtained from analysis of beef fat is presented in figure 1. The percentage of each fatty acid was computed from the area of a given peak (Keulmans, 1957).

The gas chromatography apparatus used was the same as that described by Tove and Smith (1960) except that a 12-foot column of Celite and "Reoplex 400"[6] was used. Typical operating conditions consisted of an oven temperature of 245° C. and a helium flow rate of 100 ml. per minute.

Results and Discussion

Drylot Steers. In Trial 1, the average daily gains for the animals on Rations A (control), B (2.5% fat), and C (5% fat) were 2.27 lb., 2.52 lb. and 2.42 lb., respectively. While

[6] Kindly furnished by the Geigy Chemical Company, Yonkers, New York.

TABLE 1. MEAN VALUES[a] FOR CARCASS DATA FROM STEERS IN DRYLOT RECEIVING RATIONS CONTAINING ANIMAL FAT (TRIAL 1)

Ration	Animal fat in ration	Carcass grade[b]	Ether extract in muscle[c]	Separable fat[d]	Rind thickness
	%		%	%	mm.
A	0	18.0	2.1	27.1	11.4
B	2.5	18.2	2.6	28.5	14.1
C	5.0	18.8	3.1	29.9	15.7

[a] Each value presented is the mean of six observations.
[b] 18=upper third of "good" grade; 19=lower third of "choice" grade.
[c] *Longissimus dorsi* muscle of twelfth rib.
[d] From ribs 9–10–11; includes rind fat.

both groups of steers receiving animal fat made greater gains than the control group, these differences were not statistically significant at the .05 level.

Carcass data are presented in table 1. Although values for these carcass measurements increased with each increase in the level of dietary fat, none of the differences were significant ($P>.05$). However, when the carcass data were grouped according to previous nutritional treatment of the animals and analyzed by the techniques of linear regression, it was found that addition of fat to the ration had significantly increased ($P<.05$) percentage of separable fat and rind thickness in those steers previously fed a low-energy (silage only) ration. These characteristics were not significantly affected in those steers previously receiving a ration higher in energy (silage plus corn).

TABLE 2. MEAN FATTY ACID PERCENT COMPOSITION,[a] AS DETERMINED BY GAS CHROMATOGRAPHY, OF RIB FAT FROM STEERS FED IN DRYLOT ON RATIONS CONTAINING DIFFERENT LEVELS OF ANIMAL FAT (TRIAL 1)

	Ration and % animal fat		
	Ration A	Ration B	Ration C
	0	2.5	5.0
	%	%	%
Fatty acid			
Myristic	3.5	3.7	3.3
Myristoleic	0.9	1.0	0.5
"Unknown-a"	0.4	0.4	0.1
"Unknown-b"	trace	trace	trace
Palmitic	31.8	30.6	30.6
Palmitoleic	4.6	5.0	3.4
"Unknown-c"	0.9	0.5	0.4
"Unknown-d"	trace	0.2	trace
Stearic	14.5	16.8	21.4
Oleic	42.2	41.1	40.0
Linoleic	1.2	0.7	0.3
Linolenic	trace	trace	trace
Classification of fatty acids of degree of saturation			
Total saturated acids	49.8	51.0	55.4
Total unsaturated acids	48.8	47.9	44.2
Total "unknown" acids	1.3	1.1	0.5
Classification of fatty acids of chain length			
14-carbon acids	4.4	4.7	3.8
16-carbon acids	36.4	35.6	34.0
18-carbon acids	57.9	58.6	61.7
"Unknown" acids	1.3	1.1	0.5

[a] Each value is the mean for six animals in each ration group.

Samples of rib fat from each steer were analyzed for fatty acid composition by gas chromatography. It was possible, by reference to chromatograms of standard preparations, to establish with confidence the peaks produced by the methyl esters of myristic, palmitic, stearic and oleic acids. These acids account for the greatest percent of the total fatty acids occurring in beef fat (Dugan, 1957). It was also possible to identify, with a reasonable degree of assurance, based on relative positions in the chromatograms and on published work, the peaks produced by the methyl esters of myristoleic, palmitoleic, linoleic and linolenic acids. It was not possible, within the scope of this investigation, to identify the sources of the remaining four peaks found. The substances producing these peaks are accordingly designated as "unknowns a, b, c, and d" in the order of appearance of the peaks on the chromatograms. Arachidonic acid is known to be present in minute quantities in beef fat (Dugan, 1957), but no definite peaks were obtained for this acid.

The mean fatty acid composition of rib fat samples from the steers on each level of dietary fat is presented in table 2. The fatty acids are listed in the order of the appearance of the ester peaks on the chromatogram.

Samples of the ether-extractable portions of the three rations fed in Trial 1 were analyzed in the same manner as the samples of rib fat. The percent of constituent fatty acids found in the three rations are presented in table 3.

TABLE 3. PERCENT[a] CONSTITUENT FATTY ACIDS AS DETERMINED BY GAS CHROMATOGRAPHY, IN ETHER EXTRACTS OF RATIONS FED TO STEERS IN DRYLOT (TRIAL 1)

	Ration and % animal fat		
	Ration A	Ration B	Ration C
	0	2.5	5.0
	%	%	%
Fatty acid[b]			
Myristic	0.2	1.6	2.5
Palmitic	17.7	30.3	35.2
Palmitoleic	1.0	2.8	2.7
Stearic	4.3	12.0	14.1
Oleic	38.8	42.6	42.5
Linoleic	36.4	10.7	3.1
Linolenic	1.6	trace	trace
Classification of fatty acids by degree of saturation			
Total saturated acids	22.2	43.9	51.8
Total unsaturated acids	77.8	56.1	48.2
Classification of fatty acids by chain length			
14-carbon acids	0.2	1.6	2.5
16-carbon acids	18.7	33.1	37.9
18-carbon acids	81.1	65.3	59.6

[a] Each percent value reported represents the mean of two determinations.
[b] Only those acids are reported which occurred in more than trace quantities in at least one of the rations.

It is apparent that the relative content of stearic acid in the steer rib fat increased as the fat content of the ration was increased. This effect was highly significant. The decreases in percent of oleic and linoleic acids and in the substance designated as "Unknown-c" were not significant. The previous dietary regime apparently affected the pattern of stearic acid deposition. For those steers which had been wintered on silage plus corn, the linear regression of percent of stearic acid in rib fat on percent of ether extract in the drylot ration was highly significant, with the deviation from linear being negligible. For those steers which had been wintered on silage only, the linear effect was significant, with the deviation from linear being highly significant.

It is evident from the data in table 3 that the percent of stearic acid in the ether-extractable portions of the rations increased as fat was added to the rations. It is therefore possible that the increased percent of stearic acid, observed in the rib fat as the dietary fat level was raised, can be explained on the basis of increased dietary intake of this acid. However, the amount of palmitic acid in the rations also increased markedly with each increase in level of dietary fat without any significant effect on the amount of this acid in rib fat. Furthermore, the dietary level of palmitic acid in all three rations was much higher than that of stearic acid. Some source of stearic acid other than dietary is therefore indicated.

It will be noted in table 3 that the percent of 18-carbon acids in ether extracts of the rations declined as animal fat was added. However, the percent of ether extract in the rations, on a dry-matter basis, were as follows: Ration A—1.96; Ration B—5.82; and Ration C—7.93. It therefore appears that the addition of animal fat to Ration B had the net effect of increasing the concentration of 18-carbon acids in the ration; this effect would have been even more pronounced in Ration C. References previously cited indicate that rumen microorganisms are able to hydrogenate unsaturated fatty acids. In view of these reports, the experimental results here presented suggest that the feeding of any of the straight-chain 18-carbon fatty acids to ruminants is equivalent to the feeding of at least a certain amount of stearic acid. It was reported by Barrick *et al.* (1953) that swine fed a ration containing animal grease deposited a more unsaturated back fat than control animals. The opposite tendency observed in cattle lends support to the hypothesis that these are fundamental differences in the pattern of fat utilization by ruminants and non-ruminants.

Steers on Pasture. The values presented in table 4 represent the mean fatty acid percent —composition of rib fat from steers fed on pasture in the manner previously described.

It appears that the deposition of myristic acid was significantly greater in the steers receiving added dietary fat; this was the only direct effect of ration for which significance could be demonstrated. The depression of the percentage of oleic acid deposited in those steers receiving implants of diethylstilbestrol was highly significant, and was more marked in those steers not receiving added dietary fat.

The percent of palmitic and palmitoleic acids were not found to have been significantly affected by the ration fed or by implantation with diethylstilbestrol. However, the interaction of hormone with ration was significant in respect to both of these acids. It appears that the hormone depressed the deposition of palmitic acid in the steers receiving added dietary fat, and stimulated such deposition in the steers on the high-salt ration. Conversely, the hormone implantation apparently increased palmitoleic acid deposition in steers on the high-fat ration, and decreased the dep-

TABLE 4. MEAN FATTY ACID PERCENT COMPOSITION OF RIB FAT [a] FROM PASTURE-FED STEERS, WITH AND WITHOUT DIETHYLSTILBESTROL IMPLANTATION, AND WITH ANIMAL FAT OR SALT ADDED TO GRAIN TO LIMIT INTAKE (TRIAL 2)

Grain ration	Ground corn + 10% added animal fat			Ground corn + 7–10% salt					
Diethylstilbestrol	No	Yes [b]	Mean	No	Yes [b]	Mean			
Number of animals	5	5		5	5		Statistical significance [c]		
Fatty acid: %							Ration (R)	Hormone (H)	Interaction (R x H)
Myristic	4.5	4.6	4.5	4.0	3.8	3.9	*	..	..
Myristoleic	1.9	1.8	1.9	1.8	1.3	1.6	..	..	..
Palmitic	28.6	28.0	28.3	27.2	30.4	28.8	..	..	*
Palmitoleic	7.8	8.9	8.4	8.8	7.6	8.2	..	..	*
Stearic	13.5	13.4	13.4	13.3	13.9	13.6	..	..	..
Oleic	41.3	40.2	40.8	41.9	38.6	40.2	..	**	..
All others [d]	2.4	3.1	2.8	3.0	4.3	3.6	..	..	..
16-carbon acids	36.3	36.9	36.6	56.0	38.0	37.0	..	..	..
18-carbon acids	55.2	54.2	54.7	56.0	54.9	55.5	..	..	..
Saturated acids [e]	46.5	45.9	46.2	44.4	48.5	46.5	..	..	..

[a] Duplicate determinations were made on the rib fat sample from each steer.
[b] These steers each received 24 mg. ear implants of diethylstilbestrol in the preceding fall and again in the spring before going on pasture.
[c] Analysis of variance.
[d] Includes linoleic and linolenic acids, and the four "Unknowns" reported for Trial 1.
[e] Includes myristic, palmitic and stearic acids.

osition of this acid in the steers on the high-salt ration.

Percent of palmitoleic acid found in all groups of steers fed on pasture appear to be strikingly high, in view of published values and in view of values for drylot steers obtained in this study. Hilditch (1956) states that this acid usually constitutes 2–3% of the total fatty acids in ox depot fat, while Dugan (1957) gives comparable values of 1.9–2.7% for beef tallow. The reasons for the high values obtained in this trial are unknown, but comparison with results obtained by the same analytical techniques from the drylot steers in Trial 1 suggests some cause other than methodology.

Although the results of Trial 1 and 2 were conducted at different times and a direct comparison will have to be made with some reservations, it is noteworthy that the deposition of stearic acid in the pasture-fed steers was apparently not affected by the rations fed. The deposition of myristic acid, on the other hand, was significantly affected by the rations fed to steers on pasture. The explanation for these differences in response is not as yet available. It is also apparent that the percentage of total saturated acids deposited by the pasture-fed steers in Trial 2 was lower than that of the drylot steers in Trial 1.

General. At present, one can only speculate as to the exact chemical nature of the substances producing the four unidentified peaks in the beef fat chromatograms. It is possible that these substances are branched-chain fatty acids (Hansen *et al.*, 1955a, 1955b; McInnes *et al.*, 1956), or acids with chains containing an odd number of carbon atoms (Hansen and McInnes, 1954; McInnes *et al.*, 1956). It is doubtful that these peaks are produced by artifacts arising during sample preparation, since comparable peaks have not been observed on chromatograms of fat samples from non-ruminant sources similarly prepared.

Since the beef fat samples from the steers on Trial 1 had been in storage for approximately 16 months, the question arose as to whether the constituent fatty acids had undergone any marked changes during storage. Rib fat samples from three freshly killed beef animals were therefore prepared and analyzed in the same manner as for Trials 1 and 2. Chromatograms obtained from the fresh beef fat exhibited the same pattern of peaks, including the four unidentified peaks, found in chromatograms obtained from the stored beef samples. It was concluded that the stored fat had undergone little or no change prior to analysis. This conclusion is supported by the report of Privette *et al.* (1955) that the fatty acids of beef fat undergo no appreciable oxidative deterioration during low temperature storage.

Summary

Eighteen steers in drylot were fed rations containing 0, 2.5, or 5.0% added animal fat.

Samples of rib fat from each steer were analyzed for fatty acid composition by means of gas chromatography; similar determinations were made on fatty acids in the ether extractable portions of the rations. Measurements were also made in respect to a number of carcass characteristics. The addition of animal fat to the steer rations resulted in a significant increase in percentage of separable rib fat in those animals previously receiving a low-energy ration, but not in steers wintered on a higher-energy ration; a similar situation existed in respect to thickness of rind. The addition of animal fat to the rations resulted in a highly significant increase in stearic acid content of rib fat.

Samples of rib fat from 20 pasture steers were also analyzed for fatty acid content. The deposition of myristic acid was significantly greater in steers receiving a grain ration with 10% added fat. The depression of the percent of oleic acid deposited in steers receiving implants of diethylstilbestrol was highly significant. It appears that the hormone depressed the deposition of palmitic acid in steers receiving added dietary fat, and stimulated such deposition in steers on a grain ration containing 7–10% salt; the condition was reversed in respect to palmitoleic acid deposition. The percent of palmitoleic acid was quite high in all samples of rib fat from pasture fed steers as compared to that from steers fed in drylot.

Literature Cited

A.O.A.C. 1955. Official Methods of Analysis (8th ed.). Association of Official Agricultural Chemists. Washington 4, D. C.

Arndt, F. 1935. Diazomethane. Organic Syntheses 15:3.

Barrick, E. R., T. N. Blumer, W. L. Brown, F. H. Smith, S. B. Tove, H. L. Lucas and H. A. Stewart. 1953. The effects of feeding several kinds of fat on feed lot performance and carcass characteristics of swine. J. Animal Sci. 12. (Abstr.).

Brooker, E. G. and F. B. Shorland. 1950. Studies on the composition of horse oil. I. Composition of horse oil in relation to the depot fats of other pasture-fed animals. Biochem. J. 46:80.

Dugan, L. R., Jr. 1957. Fatty acid composition of food fats and oils. American Meat Institute Foundation Circ. No. 36.

Ellis, N. R. and O. J. Hankins. 1925. Soft pork studies. I. Formation of fat in the pig on a ration moderately low in fat. J. Biol. Chem. 66:101.

Hansen, R. P. and A. G. McInnes. 1954. Volatile acids of ox perinephric fat. Nature 173:1093.

Hansen, R. P., F. B. Shorland and N. J. Cooke. 1955a. The branched-chain fatty acids of ox fat. 2. The isolation of 15-methylhexadecanoic acid. Biochem. J. 61:141.

Hansen, R. P., F. B. Shorland and N. J. Cooke. 1955b. The branched-chain fatty acids of ox fat. 3. The isolation of 14-methylpentadecanoic acid (Isopalmitic acid) from ox perinephric fat. Biochem. J. 61:547.

Hilditch, T. P. 1956. The Chemical Constitution of Natural Fats (3rd ed.). John Wiley & Sons, Inc., New York.

Hoflund, S., J. Holmberg and G. Sellmann. 1955. Investigation on fat digestion and fat metabolism in ruminants. I. Feeding unsaturated fats to dairy cows; fat digestion in rumen. Cornell Vet. 45:254.

Hoflund, S., J. Holmberg and G. Sellmann. 1956a. Investigations on fat digestion and fat metabolism in ruminants. II. Feeding unsaturated fats to dairy calves. Cornell Vet. 46:51.

Hoflund, S., J. Holmberg and G. Sellmann. 1956b. Investigations on fat digestion and fat metabolism in ruminants. III. Influence of the rumen flora on fat digestion by sheep. Cornell Vet. 46:53.

Keulemans, A. I. M. 1957. Gas Chromatography. Reinhold Publishing Co., New York 32, New York.

McInnes, A. G., R. P. Hansen and A. S. Jessop. 1956. The volatile acids of mutton fat. Biochem. J. 63: 702.

Naumann, H. D. 1951. A recommended procedure for measuring and grading beef for carcass evaluation. Report of Proceedings, 4th Annual Reciprocal Meat Conference. 89.

Orr, C. H. and J. E. Callen. 1958. Separation of polyunsaturated fatty acid methyl esters by gas chromatography. J. Am. Chem. Soc. 80:249.

Pfander, W. H. and I. S. Verma. 1957. Physical factors that influence the response of sheep to added corn oil. J. Animal Sci. 16:1087. (Abstract).

Privette, O. S., F. J. Pusch and W. O. Lundberg. 1955. Fatty acid composition and oxidative deterioration during storage, of fats in cuts of beef, lamb, pork and turkey. Food Technol. 9:347.

Reiser, R. 1951. Hydrogenation of polyunsaturated fatty acids by the ruminant. Fed. Proc. 10:236.

Reiser, R. and H. G. R. Reddy. 1956. The hydrogenation of dietary unsaturated fatty acids by the ruminant. J. Am. Oil Chem. Soc. 33:155.

Shorland, F. B., R. O. Weenick and A. T. Johns. 1955. Effect of the rumen on dietary fat. Nature 175:1129.

Thomas, B. H., C. C. Culbertson and F. Beard. 1934. The effect of ingesting soybeans and oils differing widely in their iodine numbers upon the firmness of beef fat. Proc. Am. Soc. An. Prod., 27th Annual Meeting: 193.

Tove, S. B. and F. H. Smith. 1960. Changes in the fatty acid composition of the depot fat of mice induced by feeding oleate and linoleate. J. Nutr. 71:264.

EFFECT OF FEED AND WATER INTAKE ON RUMEN AND BODY TEMPERATURES OF SHEEP UNDER SUBTROPICAL CONDITIONS [1, 2]

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THE average body temperature of sheep under normal conditions is reported by Dukes (1955) to range from 100.9° F. to 103.8° F. with an average of 102.3° F. In order to maintain this relatively constant body temperature, a sensitive balance must be maintained between heat production and heat loss. The rumen of the sheep is a source of an unknown amount of heat production. Heat produced within the rumen can be useful in maintaining normal body temperature under cool conditions but may be a deterrent under tropical conditions. High rumen temperature may, in part, be responsible for reduced appetite and general debility of mid-latitude-evolved sheep when exposed to a tropical environment. Because of the anaerobic nature of the rumen, heat production cannot be ordinarily measured by oxygen consumption techniques.

This experiment was designed to study rumen and rectal temperatures of native sheep under various conditions of feeding.

Materials and Methods

During the period June 15 to August 1, 1960, rectal and rumen temperatures were measured at ½-hour intervals during the normal working day (8:00 a.m. to 4:30 p.m.) and at 2-hour intervals during one 48-hour fasting period and two 24-hour feeding periods. Two native yearling wethers which had been sheared and fistulated 6 weeks earlier and one intact, unsheared native yearling wether were confined individually in slatted stalls within an open shed. The sheep were approximately 1 year old and weighed about 85 lb. Between trials, they were removed from the metabolism stalls and fed and watered *ad libitum*. Usually they received a 3-day rest period each week, the remainder of the week being devoted to actual experimentation. During the test periods water was made available at 2-hour intervals and was removed after 20 minutes to avoid spilling. Although temperatures were recorded throughout the entire period, data shown in the tables are for the test period only. Temperature measurements were made using a 12-channel single input thermistor type thermometer as described by Clark and Trolander (1954). Rectal and rumen temperatures of fistulated wethers were taken by inserting probes to a depth of four inches. The probes were left in position throughout the test period except that the rectal probe had to be reinserted each time after being forced out with excreta. Skin temperature was measured near the first lumbar vertebra and just off the midline. A 22-gauge hypodermic thermistor probe was used as the sensing element. A hygrothermograph was used to record ambient temperature and relative humidity. Heart rate on a 30-second basis was determined at 3- to 5-hour intervals by use of a stethoscope. The intact animal was used as a control to examine the influence of fistulation on the rectal temperature of the experimental sheep.

Results and Discussion

The average rectal temperature of the control varied by less than 0.5° F. from that of the experimental wethers. Figure 1 shows rumen and rectal temperatures as well as ambient temperature and relative humidity during the last 24 hours of the fasting period. Figures 2 and 3 present corresponding information for a 24-hour *ad libitum* feeding of a ration of rolled barley and pineapple bran [6]

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[6] Pineapple bran is the dehydrated cannery residues of pineapple, fruit, shells and trimmings.

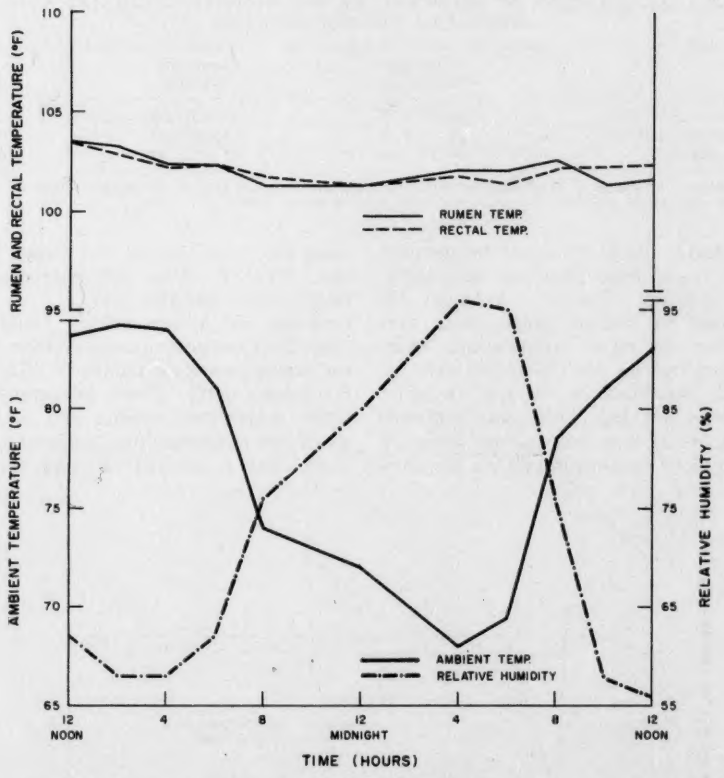

Figure 1. Temperatures and relative humidity during 24-hour fasting period.

and Napier grass (*Pennisetum purpureum*), respectively. The data reported in figures 2 and 3 represent those collected the third and fourth day after placing the animals on either feeding regime. This procedure was followed to insure minimum residual effect from the previous treatment. Table 1 shows the mean 24-hour temperatures for the same periods presented in figures 1 through 3. During the period of the experiment the environmental temperature ranged from a low of 68.0° F. to a high of 86.0° F., and the relative humidity ranged from 56% to 96%. The average rectal temperature for the two wethers was 103.0° F. Both rumen and rectal temperatures during the feeding periods were higher than those during the fasting period. The difference was highly significant ($P<.01$). During the fasting period the mean values of rumen and rectal temperatures were both 102.1° F. During the period in which barley and pineapple bran were fed, rumen temperature (104.2°

TABLE 1. AVERAGE 24-HOUR VALUES AND STANDARD ERRORS FOR RECTAL AND RUMEN TEMPERATURES FOR THREE FEEDING REGIMES[a]

Feeding regime	Fasting	Barley and pineapple bran	Napier grass
Rectal temperature, ° F.	102.1±0.21	103.4±0.23**	103.6±0.58**
Rumen temperature, ° F.	102.1±0.23	104.2±0.31**[b]	104.7±0.85**

[a] Each value is the average of 9 to 11 observations during a 24-hour period.
[b] Rumen temperature significantly different from rectal temperature ($P<.05$).
** Average significantly different from fasting temperature ($P<.01$).

TABLE 2. MEAN VALUES OF TEMPERATURE AND RELATIVE HUMIDITY AND THE STANDARD ERRORS[a] (27 DAYS)

Time	Morning (0800–1200)	Afternoon (1300–1750)	Night (1800–2400)
Rectal temperature, ° F.	103.0±0.09	103.4±0.08	102.9±0.21*
Ambient temperature, ° F.	79.5±0.38	82.4±0.33	76.9±0.81
Relative humidity, %	70.3±1.59	63.0±0.95	76.7±1.58

[a] Each value is the average of 27 observations during the night and 54 during each of the daytime periods.
* Average significantly different from afternoon rectal temperature ($P<.05$).

F.) was higher than the rectal temperature (103.4° F.) and the difference was statistically significant ($P<.05$). Although the mean values for rumen temperatures were higher than the rectal temperatures under both feeding regimes, the differences were not statistically significant in the trial in which Napier grass was fed. There was a diurnal change in rectal temperature (see table 2). The mean rectal temperature during the afternoon was 103.4° F. and that during the night was 102.9° F. This difference was statistically significant ($P<.05$).

Miller and Monge (1946) found the average body temperature ranged from 102.7° F. for Southdown-Rambouillet to 103.9° F. for Southdown ewes. These temperatures were taken during mid-summer and early spring when the environmental temperature ranged from 78.0° F. to 96.0° F. and the relative

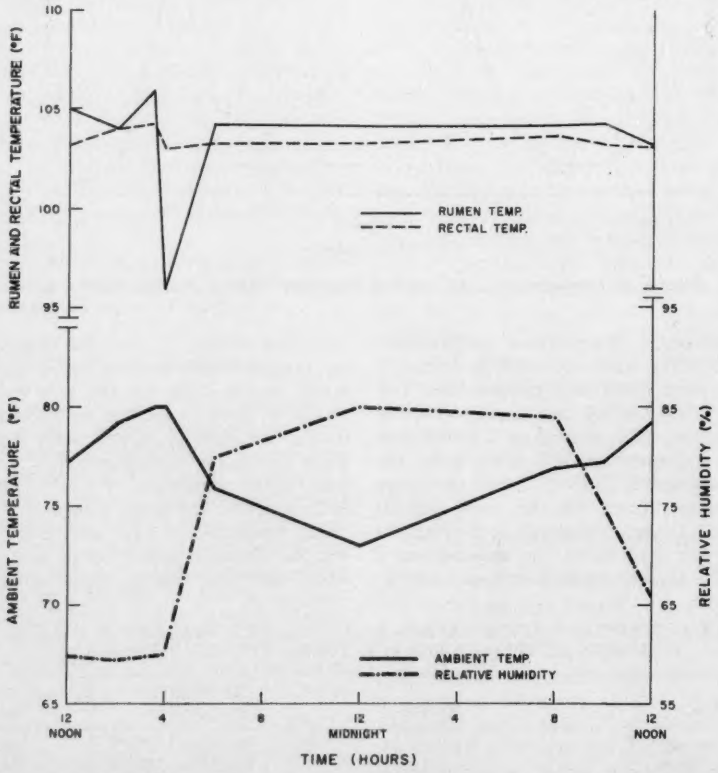

Figure 2. Temperatures and relative humidity during 24-hour ad libitum feeding. (Barley and pineapple bran)

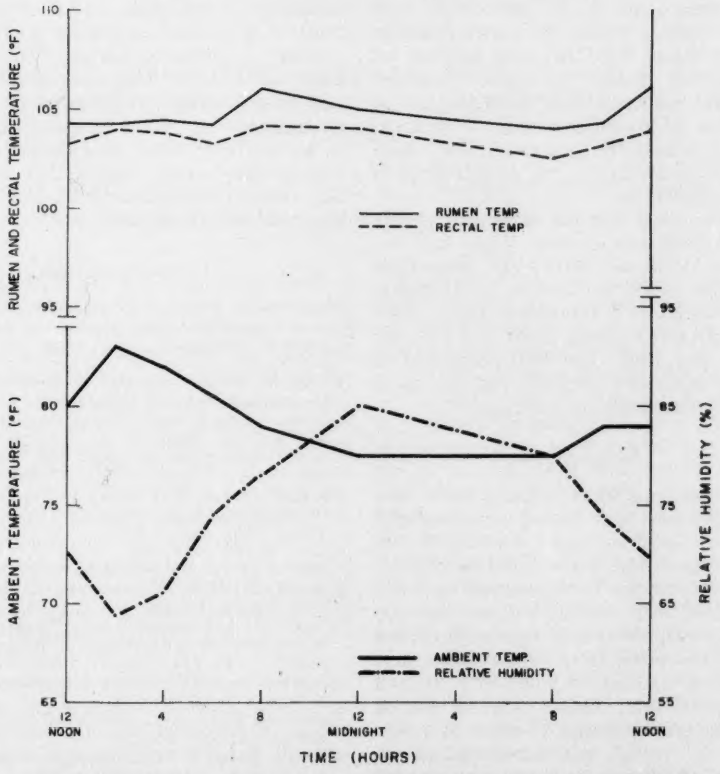

Figure 3. Temperatures and relative humidity during 24-hour ad libitum feeding. (Napier grass)

humidity ranged from 76% to 100%. Appleman and Delouche (1958) found that as the environmental temperature increased from 20° C. (68.0° F.) to 40° C. (104.0 °F.), the body temperature of four Nubian female goats increased from an average of 102.8° F. to an average of approximately 105.0° F.

During a period of 3 days, the mean skin temperature was 99.3° F. with a minimum of 95.9° F. and a maximum of 100.8° F. The pulse rate was generally 70 to 80 beats per minute, but was occasionally as high as 110 beats per minute shortly after the animals were moved from the resting pens to the metabolism stalls. The respiratory rate was 12 to 20 per minute during the cooler part of the day while fasting, but up to 75 to 100 respirations per minute during the warmer part of the day while on full-feed. These values of heart rate and respiration rate appear to be within the normal range and in agreement with those reported by Dukes (1955) and Dutt *et al.* (1959).

Water was observed to have a greater effect on rumen temperature than on rectal temperature. In one wether, when 6 lb. of water (at 77.0° F.) was consumed, the rumen temperature was observed to drop from 106.1° F. to 96.0° F. (see figure 2) in a matter of a few seconds while the rectal temperature remained constant until about 15 minutes later when it dropped one degree. In most cases, 2 to 3 hours were required for the rumen temperature to attain a plateau after the ingestion of 4 to 6 lb. of water. These findings are in agreement with those of Brody *et al.* (1955) with dairy cattle.

It is well established that European-evolved farm animals show a decline in growth rate and feed efficiency when subjected to

tropical conditions. It is conceivable that anaerobic activity within the rumen produces large amounts of heat that may account for some of this decline in vigor. However, Phillips and Spencer (1948) in their study of the reaction of Southdown sheep to two environments stress the importance of variations in adaptability to the environment in livestock production.

It would appear that the rumen can greatly affect the body temperature. When full, according to Horlacher (1927) and Kammlade (1947), the rumen can hold 20 or 25 quarts of feed; therefore, a two-degree rise in temperature of rumen ingesta could, and does, affect the heat load. The heat increment is useful in cooler environments, but may be a deterrent under tropical conditions.

Summary

Rumen temperature was found to be generally higher and more varied than the rectal temperature with a range of 10.0° F. vs. 4.0° F., respectively. Rumen and rectal temperatures during the fasting period each differed significantly ($P<.01$) from the corresponding temperatures during the *ad libitum* feeding. Rumen and rectal temperatures were lower during the last 24 hours of a 48-hour fasting period than during either of the *ad libitum* feedings. Ingestion of water at a temperature of 77.0° F. had an immediate effect upon the rumen temperature, lowering it up to 10.0° F. within minutes after drinking. The change in rectal temperature after drinking up to 6 lb. of water in each case amounted to less than 1.5° F. Rumen temperature was found to require approximately 2 hours to attain a plateau following this ingestion of water. This work shows that except during fasting or immediately after water consumption, rumen temperature of sheep is higher than rectal temperature. The results of this study suggest that the rumen may contribute an important part of the total heat load of the animal.

Literature Cited

Appleman, R. D. and J. C. Delouche. 1958. Behavioral, physiological and biochemical responses of goats to temperature, 0° C. to 40° C. J. Animal Sci. 17:326.

Brody, S., H. E. Dale and R. E. Stewart. 1955. Interrelations between temperatures of rumen (at various depths), rectum, blood, and environmental air; and the effects of an antipyretic, feed and water consumption. Mo. Agr. Exp. Sta. Bul. No. 593.

Clark, L. C. and H. Trolander. 1954. Thermometer for measuring body temperature in hypothermia. J. Am. Med. Assn. 155:251.

Dukes, H. H. 1955. The Psysiology of Domestic Animals. Comstock Publishing Co., New York.

Dutt, R. H., E. F. Ellington and W. W. Carlton. 1959. Fertilization rate and early embryo survival in sheared and unsheared ewes following exposure to elevated air temperature. J. Animal Sci. 18: 1308.

Horlacher, L. J. 1927. Sheep Production. McGraw-Hill Book Co., New York.

Kammlade, W. G. 1947. Sheep Science. J. B. Lippincott Co., New York.

Miller, J. C. and L. Monge. 1946. Body temperature and respiration rate and their relation to adaptability in sheep. J. Animal Sci. 5:147.

Phillips, R. W. and D. A. Spencer. 1948. Reactions of Southdown sheep to two environments. J. Animal Sci. 7:1.

EFFECTS OF COPPER SULFATE, COPPER OXIDE AND CHLORTETRACYCLINE ON BABY PIG PERFORMANCE [1, 2]

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Hawbaker *et al.* (1961) reported a growth response to copper sulfate with the maximum response being obtained at the 0.1% (250 ppm Cu) level. They also reported little difference in the copper content of the *longissimus dorsi* muscle but a 10-fold increase in the copper content of the livers of pigs fed 250 ppm Cu as compared with the control animals. Barber *et al.* (1957) fed high levels of copper sulfate (1.0 and 0.5%) for short periods of time (3 and 5 weeks respectively). The daily intake of feed decreased considerably and the animals failed to gain weight during the experimental period. However, as soon as the copper sulfate supplementation was reduced to 0.1% satisfactory feed intake and growth were resumed by all pigs.

The experiments reported herein were conducted to investigate further the effects of copper sulfate and to determine if copper oxide would have similar effects on the performance and fecal flora of pigs.

Experimental

The pigs in each experiment were housed in concrete-floor pens and had free access to feed and water at all times. The control rations for the experiments are presented in table 1.

The hemoglobin concentration was measured at the end of each experiment by the acid hematin method.

The data were analyzed according to analysis of variance methods. Any statements of statistical significance refer to a probability level of 5% unless otherwise noted. In all cases the pen of pigs was considered as the experimental unit in the analysis and interpretation of data.

Experiment I. One hundred and twenty-eight crossbred pigs, averaging 16 days of age and 10 lb. body weight were fed for a 4-week experimental period to study the effects of four levels of copper sulfate (0, 125, 250 and 375 ppm Cu) in the presence of two levels of protein (16 and 20%). Four replications of four pigs per pen were used in a split plot design so that litter-mate control could be maintained across copper levels (sub-plot treatments) with protein levels being the main plot treatments.

Experiment II. Eighty pigs, averaging 13 days of age and 9.5 lb. body weight, were allotted to a randomized block design involving 4 replications of 5 ration treatments. The pigs were randomly allotted, four pigs per pen, to treatments from litter-mate outcome groups. Copper was fed at the levels of 0, 125, 250 and 375 ppm as copper oxide and at 250 ppm as copper sulfate for a 6-week experimental period. Fecal flora counts were made at the end of the 6-week experimental period. These counts were made according to the methods described by Difco Laboratories, Inc. (1953). The organisms counted were coliforms, lactobacilli, total aerobes, total anaerobes, staphylococci, streptococci and molds and yeasts.

The liver and loin samples from forty pigs were assayed for copper by the method described by Andrus (1955). The tissue samples were taken from a ground mixture of the whole liver and a slice 1 in. thick from the *longissimus dorsi* in the region of the tenth rib. Duplicate analyses were made on each sample.

Experiment III. One hundred and forty-four pigs averaging 22 days of age and 14 lb. body weight were allotted to a randomized block design involving six replications of four ration treatments. The pigs were randomly allotted, four pigs per pen, to treatments from litter-mate outcome groups. The four treatments in this six-week experiment

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[3] Present address: Walnut Grove Products Co., Atlantic, Iowa.

TABLE 1. COMPOSITION OF BASAL RATIONS

	Exp. I		Exp. II & III
Protein level, %	16	22	20
Ground yellow corn	51.20	37.25	42.20
Solvent soybean oil meal (50% protein)	14.90	29.00	24.00
Oat groats	10.00	10.00	10.00
Whey (70% lactose)	15.00	15.00	15.00
Fish solubles	2.50	2.50	2.50
Stabilized lard	2.00	2.00	2.00
Vitamin premix[a]	2.00	2.00	2.00
Calcium carbonate	0.75	0.85	0.85
Dicalcium phosphate	0.95	0.70	0.75
Iodized salt	0.50	0.50	0.50
Trace mineral mixture[b]	0.20	0.20	0.20
Total	100.00	100.00	100.00

[a] Supplied supplemental vitamins so that the total ration calculated: 3000 I.U., vit. A; 500 I.U., vit. D_3; 5 mg., riboflavin; 10 mg., pantothenic acid; 30 mg., niacin; and 20 mcg., vit. B_{12} per pound of ration.
[b] Supplied the following: 140.8 ppm, Fe; 9.6 ppm, Cu; 3.2 ppm, Co; 163.2 ppm, Zn and 113.6 ppm, Mn.

were a control ration, 250 ppm of copper as copper oxide, 250 ppm of copper as copper sulfate, and 50 mg. chlortetracycline per pound of feed. Fecal flora counts were made as described in experiment II.

Results

Experiment I. A summary of the data is presented in table 2. The higher (22%) level of protein improved total gain and efficiency of feed conversion. The response to copper levels was similar on both the 16 and 22% protein groups, with maximum gains and most efficient feed conversion being observed when 250 ppm of copper was included in the diet. The quadratic regressions of gains and feed per pound of gain on copper levels were statistically significant. The hemoglobin levels of the pigs were depressed by increased copper levels; however, the depression was not as great on the level of 125 or 250 ppm as on the level of 375 ppm. The quadratic response of hemoglobin level on copper levels was statistically significant. The interaction between copper levels and protein on gains, feed conversion or hemoglobin responses was not statistically significant.

Experiment II. A summary of the data is presented in table 3. There was essentially no difference in total gain or efficiency of feed conversion by the pigs on the different copper oxide levels or between copper oxide and copper sulfate treated groups. However, there was a significant improvement observed in both total gain and efficiency of feed conversion by the pigs on all copper levels as compared with the pigs on the control ration. The hemoglobin concentration of the pigs fed copper sulfate was significantly lower as compared with all other treatments. However, copper oxide had little effect on the hemoglobin concentration. A lower hemoglobin level was observed for the pigs fed the highest level of copper oxide (375 ppm of Cu) but this difference was not statistically significant.

The amount of copper in loin tissue did not appear to be affected by the feeding of copper oxide. However, the copper content of the loin tissues of copper sulfate-fed pigs was increased 3-fold over the control animals. The feeding of copper sulfate increased the copper content of the liver 10-fold (22 vs. 218) over the control. The highest level of copper oxide fed doubled (22 vs. 44) the liver copper content as compared with the controls.

The fecal flora counts made at the end of the 6-week experimental period are presented as the log of the total count per gram of feces (table 3). The lactobacilli, total aerobic and total anaerobic counts were significantly lowered by copper sulfate. There was also a significant linear increase of total aerobic counts on copper oxide levels. The staphylococci counts varied with each copper level, this resulting in a significant cubic regression.

Experiment III. A summary of the data is presented in table 4. There was essentially no difference in total gains among the three

TABLE 2. EFFECT OF PROTEIN AND $CuSO_4 \cdot 5H_2O$ LEVELS ON PERFORMANCE OF BABY PIGS (EXPERIMENT I)[a]

Protein level, %	16				22			
$CuSO_4 \cdot 5H_2O$ level, (ppm of Cu)	0	125	250	375	0	125	250	375
Total gain per pig, lb.[b]	11.8	14.6	15.3	13.2	12.1	15.3	16.0	14.8
Feed/gain, lb.[b]	2.18	2.03	1.96	2.17	2.03	1.79	1.82	1.82
Hemoglobin, gm. %[b]	10.1	10.2	10.0	8.3	11.2	10.5	10.2	8.5

[a] 4 pens of 4 pigs each per ration treatment.
[b] Significant quadratic regression of gains, feed/gain and hemoglobin level on copper levels.

TABLE 3. COPPER SULFATE AND COPPER OXIDE FOR BABY PIGS (EXPERIMENT II) [a]

Item	Treatments				
	CuO (ppm of Cu)				$CuSO_4$ (ppm of Cu)
	0	125	250	375	250
Total gain per pig, lb.	30.3	34.3	33.4	34.4	35.4
Feed/gain, lb.	1.93	1.79	1.85	1.79	1.76
Hemoglobin, gm. %	10.1	10.3	10.0	9.7	8.6
Liver copper, ppm[b]	22	..	32	44	218
Loin copper, ppm[b]	5	..	4	6	16
Fecal flora counts,[c] log no. per gram					
Coliforms	6.35	5.78	5.75	5.67	5.83
Lactobacilli	9.50	9.50	9.70	9.38	8.20
Total aerobes	8.81	8.76	9.41	9.45	7.84
Total anaerobes	9.68	9.63	9.76	9.65	8.89
Streptococci	7.52	8.02	8.07	7.49	6.84
Staphylococci	5.47	5.31	6.68	5.62	6.10
Molds and yeasts	4.71	5.14	4.70	4.74	5.27

[a] 4 pens of 4 pigs each per ration treatment.
[b] On a dry weight basis (liver, 8 pigs per observation) (loin, 4 pigs per observation).
[c] Log of total count taken from a one gram wet sample (6 pigs per observation).

treatments (copper oxide, copper sulfate and chlortetracycline). However, all three treatments significantly ($P<.01$) increased the total gain per pig as compared with the pigs fed the control ration. None of the differences in feed conversion between the control and three treatments was statistically significant.

The hemoglobin concentration of the copper sulfate-fed pigs was significantly lower as compared with all other treatments. There were no significant differences in the hemoglobin concentration between the pigs fed the control ration and those on copper oxide and chlortetracycline-supplemented rations. Copper sulfate significantly lowered the lactobacilli and anaerobic count. The coliform counts in pigs receiving copper oxide or chlortetracycline were significantly lower as compared with the counts on pigs fed the control ration. The molds' and yeasts' counts were significantly lower in copper oxide, copper sulfate and chlortetracycline fed pigs when compared with pigs receiving the control ration.

TABLE 4. COPPER SULFATE, COPPER OXIDE AND CHLORTETRACYCLINE FOR BABY PIGS (EXPERIMENT III) [a]

Item	Treatments			
	Control	$CuSO_4$ [b]	CuO [b]	CTC [c]
Total gain per pig, lb.	32.6	38.8	37.9	38.7
Feed/gain, lb.	1.95	1.82	1.88	1.91
Hemoglobin, gm. %	10.5	10.1	10.6	10.7
Fecal flora counts,[d] log no. per gram				
Coliforms	6.16	6.44	5.58	5.91
Lactobacilli	9.20	9.03	9.36	9.30
Total aerobes	8.45	8.25	8.70	8.51
Total anaerobes	9.34	8.92	9.35	9.51
Staphylococci	5.33	5.44	5.36	5.18
Streptococci	8.26	7.95	8.25	8.40
Molds and yeasts	5.87	5.70	5.33	5.28

[a] 6 pens of 6 pigs per ration treatment.
[b] Copper compounds fed at level of 250 ppm of copper.
[c] 50 mg. of chlortetracycline per lb.
[d] Log of total count taken from a one gm. wet sample (12 pigs per observation).

Discussion

The improvement in gain obtained in these experiments when copper sulfate was added agrees with the work of Barber *et al.* (1955). They found an improvement in gain when 0.1% copper sulfate was added to the ration. Allen *et al.* (1958) also confirms the growth-promoting effect of 250 ppm of copper. However, Wallace *et al.* (1960) found that copper levels of 250 ppm and above proved toxic. The improvement in gain when copper oxide was added to the diet agrees with earlier work in which, Hawbaker *et al.* (1961) indicated that the copper radical and not the sulfate radical was producing the growth response.

Cassidy and Eva (1958) found that an inverse relationship existed between iron and copper concentration in the liver. The high levels of copper in the liver of pigs fed copper sulfate could result in a replacement of liver-iron and account for the decreased hemoglobin values observed in those groups of pigs fed high levels of copper. The fortification of the diet with iron may explain the differences in responses obtained from copper sulfate by Wallace *et al.* (1960) and the data reported herein.

The level of the protein in the diet did not

appear to affect the action of copper sulfate. Wallace *et al.* (1960) observed that as protein level was increased the toxic effect of 750 ppm of copper decreased.

Changes in the microflora were observed when copper sulfate was added to the ration. The most consistent changes were in aerobic and anaerobic counts. This agrees with the reported depressing effect of dietary copper on the number of anaerobic and/or facultative organisms by Carpenter (1948). Likewise, Hawbaker *et al.* (1961) noted changes in the fecal flora patterns as a result of high levels of copper and suggested that the changes in growth response of the pigs may be associated with the changes in intestinal flora.

Summary

Four levels of copper sulfate (0, 125, 250 and 375 ppm Cu as $CuSO_4 \cdot 5H_2O$) were fed with each of two protein levels (16 and 22%). The gain and efficiency of feed conversion were improved by both the higher (22%) protein level and copper sulfate. Maximum gain and feed efficiency resulted from 250 ppm of copper. Hemoglobin concentrations were depressed with increased copper levels. There was no significant interaction between protein level and added copper sulfate.

In the second experiment four levels (0, 125, 250, 375 ppm) of copper as copper oxide and one level (250 ppm) of copper as copper sulfate were compared. All levels of copper significantly improved feed conversion and rate of gain. Copper sulfate significantly depressed blood hemoglobin. Changes were observed in microflora patterns on the different treatments as measured by plate count techniques. The feeding of copper oxide resulted in small increases in copper content of the tissues, whereas the feeding of copper sulfate resulted in marked increases in tissue copper content.

Copper oxide (250 ppm Cu), copper sulfate (250 ppm Cu) and chlortetracycline (50 mg./lb.) significantly improved total gain as compared to the control ration. Copper sulfate significantly depressed the hemoglobin concentration. The fecal flora patterns were also altered by these ration supplements.

Literature Cited

Allen, M. M., R. S. Barber, R. Braude and K. G. Mitchell. 1958. Copper and zinc supplements for fattening pigs. Proc. Nutr. Soc. (British) 17:XII.

Andrus, S. 1955. Determination of copper in plant materials by means of zinc debenzldithiocarbonate. Analyst. 80:514.

Barber, R. S., R. Braude and K. G. Mitchell. 1955. Antibiotics and copper supplements for fattening pigs. British J. Nutr. 9:378.

Barber, R. S., R. Braude, K. G. Mitchell and J. A. F. Rook. 1957. Further studies on antibiotic and copper supplements for fattening pigs. British J. Nutr. 11:70.

Carpenter, L. E. 1948. The copper requirements for swine. Hormel Institute of the Univ. of Minnesota Annual Report. 1947/1948:21.

Cassidy, J. and J. K. Eva. 1958. Relationship between copper and iron concentration in pig's livers. Proc. Nutr. Soc. 17:XXXI. (Abstr.)

Difco Laboratories, Inc. 1953. Difco Manual of Dehydrated Culture Media and Reagents for Microbiological and Clinical Laboratory Procedures. 9th ed. Detroit, Mich.

Hawbaker, J. A., V. C. Speer, V. W. Hays and D. V. Catron. 1961. Effect of copper sulfate and other chemotherapeutics in growing swine rations. J. Animal Sci. 20:163.

Wallace, H. D., J. T. McCall, Billy Bass and G. E. Combs. 1960. High level copper for growing-finishing swine. J. Animal Sci. 19:1153.

EFFECT OF STRESS FROM ELECTRICAL STIMULATION AND SUGAR ON THE CHEMICAL COMPOSITION OF SWINE CARCASSES [1]

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THE shrinkage that occurs when pigs are shipped to market has caused large losses to hog producers. The packer frequently receives hogs that have lost considerable weight and are fatigued. Management practices that would decrease shipping losses and increase carcass quality of swine would be beneficial to the packer and to the hog producer.

Heck (1957) published data that indicated the addition of brown sugar to the drinking water of hogs reduced shipping losses. Gibbons and Rose (1950) have shown that fatigue caused a high pH in pork muscle. Preliminary work at the Arkansas Experiment Station indicated that the stress received from periodic electrical stimulation for approximately 5 hours prior to slaughter produced a weight loss comparable to that obtained when hogs were shipped 125–250 miles. This type of stress also produced a high pH in pork muscle. It was also observed that the addition of 10% brown sugar to the drinking water for 48 hours prior to slaughter produced more fill than the feeding of 0, 2½, or 5% brown sugar. With this in mind, an experiment was designed to determine the effect of stress received from periodic electrical stimulation and/or the addition of brown sugar to the drinking water prior to slaughter on certain carcass characteristics and on the chemical composition of various muscles in swine.

Experimental

After an 18-hour shrink, forty No. 1 crossbred hogs, weighing between 188 and 236 lb., were grouped according to sex into groups of four, differing in weight by less than 10 lb. They were then allotted at random to four treatments in a 2 x 2 factorial experiment. Lots 1 and 2 received no sugar in their drinking water, while the pigs in lots 3 and 4 received 10% (w/w) brown sugar for 48 hours. During this period the feed and water consumed and the increase in weight were recorded. The increase in weight during this 48-hour period was designated as fill. All pigs were then shrunk for approximately 5 hours without feed and water. The decrease in weight during this period was designated as live shrink. The pigs in lots 2 and 4 received three electric shocks every 10 minutes from an "electric hotshot" during this 5-hour period while the pigs in lots 1 and 3 were placed in a pen and not disturbed until they were slaughtered.

Live shrink was expressed on a rate basis (lb./hr.). At time of slaughter, liver weight, weight of the warm carcass and pH of three muscles were taken at the following locations: *longissimus dorsi*—at the 13th rib; the *psoas major*—at the 3rd sacral vertebra; and the *quadriceps femoris*—at the 3rd sacral vertebra.

Cooler shrink was obtained after chilling for 24 hours at 37–39° F. After a 48-hour chill the pH was again determined on the above muscles; weights of the ham, loin, side, and shoulder were obtained and photographs were taken of the hams. These photographs were used to determine the degree of two-toneness at a later date by a panel of staff members. The classification of the two tones in the hams were as follows: I—designated a ham that was not two-toned. The muscles were dark in color and very firm; II—designated a ham that was slightly two-toned. The outer muscles were light in color while the muscles next to the bone were dark. These muscles were moderately firm and slightly watery immediately after cutting; III—designated muscles that were two-toned. The outer muscles were very light in color, soft and watery in appearance. The muscles next to the bone were lighter than the corresponding muscles in the two preceding classifications.

The pH was determined on the above muscles by placing a 2 gm. sample of muscle in a 5 ml. beaker with 3 ml. distilled water. The electrodes were inserted into the muscle and

[1] Published with the approval of the Director of the Arkansas Agricultural Experiment Station.

the pH was determined with the Beckman Model G pH meter.

It was found that expressing the pH values as hydrogen ion concentration produced results that were very similar. This was done in order to compare the results using the hydrogen ion concentration with the pH, since the pH is a logarithmic function of the hydrogen ion concentration. Simple correlations between pH and hydrogen ion concentration were found to be above 0.90.

as much fat as possible, ground and frozen until chemical analysis could be determined.

Cooking losses were determined on each muscle by cooking an 8 to 10 gm. sample of meat in an 8 dram vial on a raised wire screen for 1 hour at 300° F.

Fat was expressed on a fresh weight basis; protein and ash on a fat-free, carbohydrate-free dry matter basis; moisture on a fat-free, carbohydrate-free basis; and glycogen and lactic acid on a fat-free dry matter basis.

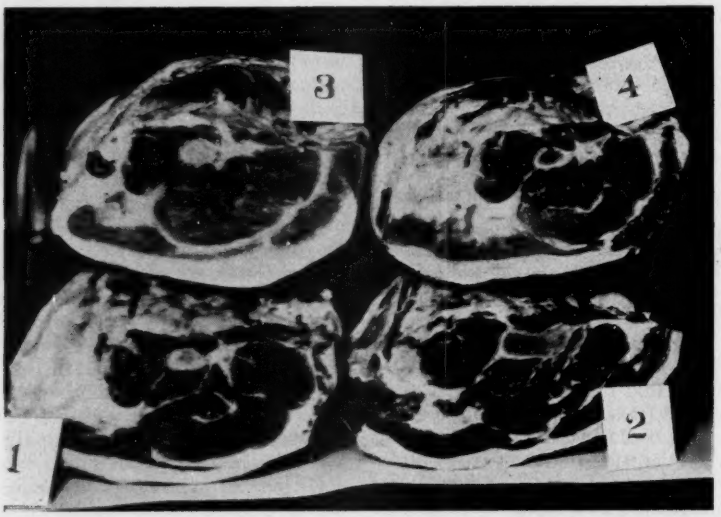

Figure 1. The effect of periodic electric shock treatment and/or sugar feeding prior to slaughter on the color of fresh hams. Hams numbered 1, 2, 3, and 4 are from animals in lots 4, 2, 3, and 1, respectively.

Samples of the liver and the above muscles were obtained and frozen for later analysis of moisture, protein, fat, ash, glycogen and lactic acid. Moisture, fat, protein and ash were analyzed by methods of A.O.A.C. (1955). Glycogen was extracted as described by Pfluger (1905) and the resulting precipitate was determined photometrically using the anthrone method of Carroll *et al.* (1956). Lactic acid determinations were made by the method of Barker and Summerson (1941).

Part of the muscle sampled for chemical analysis was: *longissimus dorsi*—between the 7th and 13th ribs, the *psoas major*—the part of the muscle in the loin cut, and the *quadriceps femoris*—the part of the muscle in the ham. These samples were trimmed to remove

Dressing percent was expressed on the initial shrunk basis using the hot carcass weight to do away with any differences in fill at slaughter and any differences in cooler shrink. Initial weight basis was the weight taken at the beginning of the experiment after an 18-hour shrink period. Statements regarding significance of differences are based on analyses of variance.

Results and Discussion

Carcass Characteristics. Table 1 shows the effect of stress and sugar feeding prior to slaughter on certain carcass characteristics of swine. The addition of 10% brown sugar to the drinking water for 48 hours significantly increased the water consumption from 12 to

34 lb./pig/day and significantly decreased the feed consumption from 9 to 5 lb./pig/day. This decrease in feed consumption is not surprising because the total weight of feed consumed, including the sugar that was fed in the drinking water, was approximately the same. Heck (1957, 1958) has also suggested an increased water consumption when sugar was added to the drinking water. The increased water consumption was reflected by a significant increase in the amount of fill in each animal receiving sugar in their drinking water.

None of the treatments produced significant changes in live-shrink; 24-hour cooler-shrink; liver weight; or yield of the ham and shoulder. *et al.* (1953) and Wilcox *et al.* (1953) reported significant increases in dressing percent when sugar was fed to swine and cattle, while Heck (1958) reported significant decreases in dressing percent. Heck (1958) also indicated a significant decrease in yield due to significantly increased cooler-shrink of the sugar fed hogs. Neither Wilcox *et al.* (1953) nor Greenwood *et al.* (1953) reported cooler-shrink values.

Stress prior to slaughter significantly decreased the two-toned score of the hams. Figure 1 shows an example of the effect of the various treatments on the color of the fresh hams. Sugar feeding had no consistent effect

TABLE 1. EFFECT OF STRESS AND SUGAR FEEDING PRIOR TO SLAUGHTER ON CERTAIN CARCASS CHARACTERISTICS OF SWINE

Treatment	Control	Stress	Sugar fed	Stressed + sugar fed	Significant variation due to		
Lot no.	1	2	3	4			
No. animals	10	10	10	10	Sugar	Stress	Interaction
Av. wt., lb.	204	204	203	203	..	..	..
Av. daily feed consumption, lb.	9	...	5	...	**	..	..
Av. daily water consumption, lb.	12	...	34	...	**	..	..
Fill, %	3.9	...	5.4	...	*	..	..
Shrink, lb./hr.	0.9	1.3	1.1	1.2	..	..	..
Dressing, %	76.4	76.4	76.1	78.5	..	..	..
Wt. of liver, lb.	3.3	3.4	3.5	3.6	..	..	..
24 hour cooler shrink, %	1.7	2.4	2.5	2.5	..	..	..
Two-toned ham score[a]	2.9	1.6	2.8	1.8	..	**	..
Primal cuts:							
% Ham	17.5	17.6	17.4	17.1	..	..	..
% Loin	17.3	16.7	17.7	17.7	*	..	..
% Side	11.8	12.8	11.8	12.1	..	*	..
% Shoulder	16.8	16.2	16.0	15.9	..	..	..

[a] 1=not two-toned, 2=slightly two-toned, 3=two-toned.
* $P<.05$.
** $P<.01$.

Heck (1957) indicated a significant decrease in live-shrink in hogs fed sugar in their drinking water for 48 hours prior to shipping. The reason for the difference in response may have been due to the treatment of the animals after the shrink period. The animals used by Heck (1957) were allowed free access to feed and water before shrunk weights were obtained, while the animals reported here were weighed immediately after shrinking. Greenwood *et al.* (1953) have reported significant increases in the weight of livers of cattle and hogs fed sugar while Wilcox *et al.* (1953) have presented data indicating significant weight increases in beef liver and increased size in hog livers when sugar was fed. Heck (1958) has reported no significant changes in the weight of hog livers when sugar was fed. Greenwood on the color but stress prior to slaughter consistently darkened the color of these hams. Briskey *et al.* (1958, 1959a, 1959b, 1960) have also reported that exercise would produce darker colored hams. Various workers have shown that insulin shock, electric stimulation, and injection of adrenalin would produce dark cutting beef (Bouton *et al.*, 1957; Hall *et al.*, 1944; Hedrick, *et al.*, 1957; Hedrick, 1958; Howard and Lawrie, 1957a, b; Lawrie, 1958; Mackintosh and Hall, 1934). Slight increases in brightness of beef and pork when sugar was fed have been reported (Greenwood *et al.*, 1953; Wilcox *et al.*, 1953). Briskey *et al.* (1958, 1959b, 1960) have reported that the feeding of high sucrose rations for 2 weeks prior to slaughter produced pale-watery pork.

A significant yield in loin was associated

TABLE 2. CHANGE IN pH OF THE *LONGISSIMUS DORSI, PSOAS MAJOR,* AND *QUADRICEPS FEMORIS* MUSCLES DUE TO STRESS AND SUGAR FEEDING PRIOR TO SLAUGHTER

Lot no.	Control 1	Stress 2	Sugar fed 3	Stress + sugar fed 4	Significant variation due to		
					Sugar	Stress	Interaction
Time after slaughter:							
30 min.:							
Longissimus dorsi[a]	6.4	6.5	6.5	6.5	..	..	..
Psoas major[b]	6.5	6.7	6.5	6.5	..	..	..
Quadriceps femoris[b]	6.5	6.8	6.4	6.6	..	*	..
48 hours:							
Longissimus dorsi[b]	5.6	6.0	5.7	5.9	..	**	..
Psoas major[c]	6.0	6.5	5.9	6.4	..	**	..
Quadriceps femoris[c]	5.9	6.4	5.9	6.3	..	**	..

[a] Eight pigs/lot.
[b] Nine pigs/lot.
[c] Ten pigs/lot.
* P<.05.
** P<.01.

with sugar feeding and a significant yield of side was associated with stress prior to slaughter. There was no ready explanation for the difference in yield of primal cuts due to the various treatments. However, unpublished data from the Arkansas Experiment Station support these effects.

Table 2 shows the change of the pH of the *longissimus dorsi, psoas major* and *quadriceps femoris* muscles due to the various treatments. Thirty minutes after slaughter none of the treatments had significantly affected the pH of either the *longissimus dorsi* or the *psoas major* muscles. Stress prior to slaughter significantly increased the pH of the *quadriceps femoris* muscle 30 minutes after slaughter and also significantly increased the pH of all three muscles 48 hours after slaughter. Sugar feeding had no significant effect on the pH of any of these muscles at either 30 minutes or 48 hours after slaughter. Various workers have reported slight or no changes in pH from either cattle or hogs that received sugar (Greenwood *et al.,* 1953; Rose and Peterson, 1951; Madsen, 1943; Wilcox *et al.,* 1953). It has been shown that any treatment that will cause fatigue, i.e. either from exhaustive exercise or from shipping long distances, produced pork with a high pH (Gibbons and Rose, 1950; Briskey *et al.,* 1958, 1959a, 1959b, 1960; Callow, 1938, 1939.).

Cooking Losses. Table 3 shows the relationship between stress and sugar feeding prior to slaughter and the cooking losses of samples from the three previously mentioned muscles. Periodic electric shock treatment significantly decreased the dry matter loss in all three muscles and significantly decreased the moisture loss in the *psoas major* and *quadriceps femoris* muscles. In the *longissimus dorsi* muscles, sugar feeding had no significant effect on cooking losses. There was a significant

TABLE 3. EFFECT OF STRESS AND SUGAR FEEDING PRIOR TO SLAUGHTER ON THE COOKING LOSSES OF THE *LONGISSIMUS DORSI, PSOAS MAJOR* AND *QUADRICEPS FEMORIS* MUSCLES

Lot no.	Control 1	Stress 2	Sugar fed 3	Stress + sugar fed 4	Significant variation due to		
No. animals	10	10	10	10	Sugar	Stress	Interaction
Dry matter loss: %							
Longissimus dorsi	3.2	1.8	2.6	2.3	..	**	**
Psoas major	2.1	1.2	2.3	1.7	..	**	..
Quadriceps femoris	2.2	1.5	2.3	1.6	..	**	..
Total moisture loss: %							
Longissimus dorsi	46.0	44.6	46.6	43.6	..	..	..
Psoas major	46.0	38.3	46.5	41.8	..	**	..
Quadriceps femoris	48.8	42.8	46.7	39.9	..	**	..

* P<.05.
** P<.01.

TABLE 4. CHEMICAL COMPOSITION OF THE *LONGISSIMUS DORSI, PSOAS MAJOR* AND *QUADRICEPS FEMORIS* MUSCLES AND OF THE LIVER FROM SWINE THAT HAVE RECEIVED STRESS AND SUGAR PRIOR TO SLAUGHTER

Lot no.	Control 1	Stress 2	Sugar fed 3	Stress + sugar fed 4	Significant variation due to		
No. animals	9	9	9	9	Sugar	Stress	Interaction
Moisture, % [a]							
Liver	74.9	75.8	77.4	77.1	**	..	..
Longissimus dorsi	76.6	76.7	76.4	76.4	..	..	..
Psoas major	78.4	77.9	78.2	78.1	..	..	..
Quadriceps femoris	77.7	77.7	77.8	77.7	..	..	..
Protein, % [b]							
Liver	93.6	93.6	93.2	93.4	**	..	..
Longissimus dorsi	95.2	95.2	95.2	95.3	..	..	..
Psoas major	94.9	94.9	94.8	94.8	..	..	..
Quadriceps femoris	94.9	94.9	94.8	94.8	..	..	..
Ash, % [b]							
Liver	6.4	6.4	6.8	6.6	**	..	..
Longissimus dorsi	4.8	4.8	4.8	4.7	..	..	..
Psoas major	5.1	5.1	5.2	5.2	..	..	..
Quadriceps femoris	5.1	5.1	5.2	5.2	..	..	..
Fat, % [c]							
Liver	3.7	3.0	3.0	3.6	..	..	..
Longissimus dorsi	4.4	4.9	4.3	4.8	..	..	..
Psoas major	2.4	2.7	2.5	2.5	..	..	..
Quadriceps femoris	2.2	2.4	2.4	2.4	..	..	..
Glycogen, mg./gm. [d]							
Liver	19.04	27.19	67.51	41.08	..	..	..
Longissimus dorsi	1.39	1.08	4.51	0.45	..	..	..
Psoas major	1.11	0.22	3.89	0.92	*	*	..
Quadriceps femoris	0.25	0.13	1.10	0.56	..	..	..
Lactic acid, mg./gm. [d]							
Liver	4.95	5.55	5.34	4.15	..	..	..
Longissimus dorsi	38.63	32.06	40.88	33.98	..	..	..
Psoas major	31.91	15.01	34.31	15.85	..	**	..
Quadriceps femoris	28.72	10.99	33.25	12.00	..	**	..
Total composition, % [c]							
Liver	98.1	97.6	97.5	97.9	..	..	..
Longissimus dorsi	101.4	101.4	101.2	101.5	..	..	..
Psoas major	100.8	100.9	100.2	100.8	..	..	..
Quadriceps femoris	101.3	100.9	100.4	101.3	..	..	**

[a] Fat-free, carbohydrate-free basis.
[b] Fat-free, carbohydrate-free, moisture-free basis.
[c] Fresh wt. basis.
[d] Fat-free dry matter basis.
* $P < .05$.
** $P < .01$.

interaction between periodic electrical stimulation and sugar feeding in the dry matter loss of the *longissimus dorsi* muscle. These results on the *longissimus dorsi* muscle are surprising since there was no accompanying significant change in either the pH or the lactic acid concentration of this muscle when sugar was fed while there were significant changes in the pH and lactic acid concentrations of the muscles in the animals receiving stress.

The reason for stress decreasing cooking losses might be explained in the following manner: Various workers have demonstrated that as the muscle pH increases there is also an accompanying increase in water binding capacity of the muscle proteins. (Grau *et al.*, 1953; Swift *et al.*, 1958; Wierbicki and Deatherage, 1958; Wierbicki *et al.*, 1957). Since stress prior to slaughter caused a significant increase in muscle pH, it seems reasonable to expect moisture loss in cooking to be decreased by this treatment prior to slaughter. The dry matter cooking loss was also probably decreased by this treatment because as the moisture loss was decreased, the soluble dry matter in this moisture would also decrease.

Chemical Composition. Table 4 shows the chemical composition of the *longissimus dorsi, psoas major* and *quadriceps femoris* muscles and of the liver from swine that have received stress and sugar prior to slaughter. The addition of 10% sugar to the drinking water for 48 hours significantly increased the moisture and ash content of the liver; significantly increased the glycogen content of the *psoas major* muscle; and significantly decreased the protein content of the liver. There was no significant difference in the ash and protein concentration of the liver when expressed on a fat-free dry matter basis. Greenwood *et al.* (1953) indicated no effect of sugar feeding on the carbohydrate content of either the liver or muscle while Wilcox *et al.* (1953) suggested that sugar feeding slightly increased the carbohydrate content of the liver and muscle. The liver samples were taken at time of slaughter by both groups of workers but there was no indication as to whether precautions were taken to stop glycolysis at time of sampling. Briskey *et al.* (1958, 1959b, 1960) reported that the feeding of high levels of sucrose increased the glycogen content of the muscles at time of slaughter but had no significant effect on the glycogen content after a 24-hour chill. The data presented here, which were obtained from samples taken 48 hours after slaughter, are in partial agreement with the above work.

Stress prior to slaughter significantly decreased the lactic acid in the *psoas major* and *quadriceps femoris* muscle and decreased the glycogen in the *psoas major* muscle. Stress had no significant effect on the chemical composition of any of the other muscles. There was also a significant interaction between sugar feeding and stress prior to slaughter on the total chemical composition of the *quadriceps femoris* muscle. This is in agreement with work published by Gibbons and Rose (1950) and Rose and Peterson (1951). The increase in the pH of the stressed animals can be explained by the decreased concentration of lactic acid.

Similar results were obtained when the ratios of the chemical composition of the *longissimus dorsi, psoas major* and *quadriceps femoris* muscles and of the liver were calculated. However, there were no significant differences in the liver due to treatments when the composition was expressed on an absolute weight basis. These results were surprising, since there were significant changes in the percent composition of the liver due to sugar feeding. The authors have no explanation for this but feel that the statistical analysis in which absolute values were used was the most accurate.

Since the data presented here indicated that there was significantly less dry matter lost in cooking meat from animals that have received periodic electrical stimulation just prior to slaughter and since later data obtained at this station have indicated that the tenderness of some pork muscles are increased by this treatment (Lewis *et al.*, 1959), it would seem unnecessary to rest pigs prior to slaughter in order to improve carcass quality. With modern refrigeration equipment the increase in pH would not seem to predispose excessive spoilage during curing and processing if adequate precautions are taken.

Summary

Stress received from periodic electrical stimulation for approximately 5 hours prior to slaughter significantly increased yield of side and the pH of the *longissimus dorsi, psoas major, quadriceps femoris* muscles. The two toned score of the ham, cooking losses of these three muscles, lactic acid concentration of the *psoas major* and *quadriceps femoris* muscles and the glycogen concentration of the *psoas major* muscle were significantly decreased. The addition of 10% sugar to the drinking water for 48 hours prior to slaughter significantly increased the water consumption, amount of fill, yield of loin, moisture and ash content of the liver and the glycogen content of the *psoas major* muscle. Feed consumption and the protein content of the liver were significantly decreased. There was a significant interaction between sugar and stress in the dry matter lost in cooking. A combination of stress and sugar feeding prior to slaughter significantly increased the dry matter lost in cooking the *longissimus dorsi* muscle while sugar feeding alone significantly decreased the dry matter lost in cooking this muscle. None of the treatments had a significant effect on live shrink, weight of the liver, dressing percent, or the yield of the ham or the shoulder.

Literature Cited

A.O.A.C. 1955. Official Methods of Analysis (8th ed.). Association of Official Agricultural Chemists. Washington, D. C.

Barker, S. B. and W. H. Summerson. 1941. The colorimetric determination of lactic acid in biological material. J. Biol. Chem. 138:535.

Bouton, P. E., A. Howard and R. A. Lawrie. 1957. Studies on beef quality VI. Effects on weight losses

and eating quality of further pre-slaughter treatments. Australian Div. of Food Preserv. and Transportation Tech. Paper 6:5.

Briskey, E. J., R. W. Bray, W. G. Hoekstra, R. H. Grummer and P. H. Phillips. 1959a. The effect of various levels of exercises in altering the chemical and physical characteristics of certain pork ham muscles. J. Animal Sci. 18:153.

Briskey, E. J., R. W. Bray, W. G. Hoekstra, P. H. Phillips and R. H. Grummer. 1958. The effect of high protein, high fat, and high carbohydrate rations on the water binding properties of pork muscles. J. Animal Sci. 18:153.

Briskey, E. J., R. W. Bray, W. G. Hoekstra, P. H. Phillips and R. H. Grummer. 1959b. The effect of exhaustive exercise and high sucrose regimen on certain chemical and physical pork ham muscle characteristics. J. Animal Sci. 18:173.

Briskey, E. J., R. W. Bray, W. G. Hoekstra, P. H. Phillips and R. H. Grummer. 1960. Effect of high protein, high fat, and high sucrose rations on the water binding and associated properties of pork muscle. J. Animal Sci. 19:404.

Callow, E. H. 1938. The after effects of fasting. Food Inv. Board Ann. Rpt. p. 54.

Callow, E. H. 1939. The pH of muscular tissue. Food Inv. Board Ann. Rpt. p. 27.

Carroll, N. V., R. W. Langley and J. H. Roe. 1956. The determination of glycogen in liver and muscle by use of anthrone reagent. J. Biol. Chem. 220: 583.

Gibbons, N. E. and D. Rose. 1950. Effect of antemortem treatment of pigs on quality of wiltshire bacon. J. Can. Res. 28:438.

Grau, R., R. Hamm and A. Baumann. 1953. Über das Wasserbindungavermogen des toten Saugetiermuskel I. Der Einfluss des pH—Wertes auf die Wasserbinding vom zerklienertem Rindermuskel. Biochem. Z. 325:1.

Greenwood, D. A., E. B. Wilcox, H. Stiffen, L. E. Harris and L. Shupe. 1953. Feed supplements-sugar: Influence on animal carcass of feeding sugar. J. Agr. Food Chem. 1:1112.

Hall, J. L., E. E. Latschar, D. L. Macintosh. 1944. Dark cutting beef. Kans. Agr. Exp. Sta. Tech. Bul. 58, Part IV.

Heck, M. C. 1957. Feeding sugar to hogs to cut shipping losses. Ark. Farm Res. 6:2.

Heck, M. C. 1958. Influence of pre-slaughter feeding and holding on meat quality. 10th Res. Conf. Proc. 10:41.

Hedrick, H. B. 1958. Etiology and possible preventive measures in the dark cutter syndrome. Vet. Med. 53:466.

Hedrick, H. B., D. E. Brady and C. W. Turner. 1957. The effect of ante-mortem stress on post-mortem beef carcass characteristics. Proc. of the 9th Res. Conf. 9:9.

Howard, A. and R. A. Lawrie. 1957a. Studies on beef quality II. Physiological and biochemical effects of various pre-slaughter treatments. Australian Div. of Food Preserv. and Transportation Tech. Paper 2:18.

Howard, A. and R. A. Lawrie. 1957b. Studies on beef quality V. Further observations on biochemical and psysiological responses to pre-slaughter treatments. Australian Div. of Food Preserv. and Transportation Tech. Paper 4:1.

Lawrie, R. A. 1958. Physiological stress in relation to dark cutting beef. J. Food and Agr. 9:721.

Lewis, Jr., P. K., C. J. Brown and M. C. Heck. 1959. The effect of periodic electric shock prior to slaughter on the eating quality of fresh and cured pork. J. Animal Sci. 18:1477.

Mackintosh, D. L. and J. L. Hall. 1934. Color of beef. Kans. Exp. Sta. Rpt. to Conf. on Coop. Meat Invest. p. 22.

Madsen, J. 1943. Investigation on the keeping quality of pork from animals which have been fed feed containing sugar. Nord. Jordburgaforskning 5–6:340.

Pfluger, E. F. W. 1905. Das Glykogen und seine Beziehungen zur Zuckerkrankheit (2nd ed.). Bonn.

Rose, D. and R. Peterson. 1951. Depletion of carbohydrate reserves by starvation and exercise. Can. J. Technol. 29:421.

Swift, C. E., M. D. Berman and R. J. Gibbs. 1958. Water holding, pH and other variable properties of beef muscles. Food Technol. (Supp. 4). 12:26.

Wierbicki, E. and F. E. Deatherage. 1958. Determination of water-holding capacity of fresh meats. J. Agr. and Food Chem. 6:387.

Wierbicki, E., L. Kunkle and F. E. Deatherage. 1957. Determination of water holding capacity and cation shifts during heating and freezing and thawing of meat as revealed by a simple centrifuge method for measuring shrinkage. Food Technol. 11:69.

Wilcox, E. B., M. B. Markley, L. S. Galloway, D. A. Greenwood, W. Binns, J. A. Bennett and L. E. Harris. 1953. The effect of feeding sucrose to beef cattle and swine on the dressing percentage and quality of meat. J. Animal Sci. 12:24.

LYSINE SUPPLEMENTATION OF SORGHUM GRAIN-COTTONSEED MEAL RATIONS FOR GROWING-FATTENING PIGS [1, 2]

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KUIKEN and Lyman (1948) reported that availability of lysine in a sample of cottonseed flour was 64.5% whereas in wheat and peanut flour it was about 95%. The formation of a gossypol-protein complex could account for this decreased lysine availability and consequent lowered nutritional value of the cottonseed protein. A number of investigators have shown that lysine is indispensable for the growth and development of young pigs. Lysine requirement for growing pigs has been reported by Mertz *et al.* (1949), Brinegar *et al.* (1950) and Shelton *et al.* (1951).

Most of the data in the literature concerning the effect of adding lysine to swine rations are based on experiments with corn as the principal grain and with soybean meal as the protein supplement, or with grain sorghum and soybean meal. (Pond *et al.* 1953).

The experiments reported here were conducted to determine whether a sorghum grain-cottonseed meal ration containing 16% crude protein could be improved by varying levels of added lysine. A second purpose was to determine whether the effect of lysine supplementation would be the same with cottonseed meals which varied in protein quality.

Experimental

Animals. The pigs used in these tests were purebred Durocs bred and raised by the Texas Agricultural Experiment Station. They averaged 42 lb. initial weight in experiment 1 and approximately 58 lb. in experiment 2. The pigs had been treated against cholera and were treated for round worms (ascarids) before placing on test. The pigs were allotted to treatment according to initial weight, sex and apparent thrift. The pigs were kept and fed in individual pens with concrete floors and with an outside concrete pen adjacent to the pen inside the feeding shed. Both the inside and the outside pens were 4 ft. by 8 ft. Each pen inside the barn contained an individual self-feeder and each outside pen contained an individual water trough. Weekly weights and feed consumption of the pigs were recorded. All pigs that died were autopsied.[3]

Rations. The composition of the control rations is given in table 1.

When the commercial lysine supplement containing 42% crude protein was added, the amount of cottonseed meal and milo was adjusted to keep the crude protein content of the rations at a 16% level. The lysine content of the commercial lysine feed supplements used in experiments 1 and 2 was 21.8% and 20.0% respectively.

Chemical Characteristics of the Cottonseed Meals. The solubility of the cottonseed meal protein in 0.02N sodium hydroxide was determined by the method of Lyman *et al.* (1953). Total and free gossypol were determined by the official methods of the American Oil Chemists Society (1957). Lysine with free epsilon amino groups was determined by the method of Baliga *et al.* (1959). Total lysine was determined microbiologically with *Leuconostoc mesenteroides* as the test organism, as described by Lyman *et al.* (1956).

The chemical characteristics of the cottonseed meals used in the tests are given in table 2. The free gossypol content of all three meals was low (0.02% to 0.03%) indicating that no difficulty due to gossypol toxicity would be expected. The total lysine content was about the same in all meals but the lysine with free epsilon amino groups was markedly lower in the meal of low-protein quality used in the first experiment. That low levels of lysine with free epsilon amino groups are indicative of low-protein quality has been shown by Baliga *et al.* (1959).

Baliga and Lyman (1957) and Lyman *et al.* (1959) have shown that reduction in free lysine epsilon amino groups in cottonseed meal can be brought about by reaction with gossypol to form bound gossypol.

Nitrogen solubility has been used as an indicator of protein quality in cottonseed meal

[1] This investigation was supported in part by a grant-in-aid from the National Cottonseed Products Association.

[2] Departments of Animal Husbandry and Biochemistry and Nutrition.

[3] Autopsies were performed by H. E. Redmond, School of Veterinary Medicine.

TABLE 1. CONTROL RATIONS FOR LYSINE SUPPLEMENTATION TESTS

Ingredients	Experiment I Group I	Experiment I Group V	Experiment II Group I
	lb.	lb.	lb.
Ground milo	70.4	73.4	72.0
Cottonseed meal (low quality)	22.6	....	....
Cottonseed meal (high quality)	....	19.6	....
Cottonseed meal	....	....	21.0
Alfalfa leaf meal	4	4	4
Limestone	1.5	1.5	1.5
Salt	0.5	0.5	....
Trace mineral-salt mixture [a]	....	....	0.5
Antibiotic premix [b]	1	1	....
Vitamin-antibiotic premix [c]	....	....	1.0
Zinc sulfate	2.5 gm.	2.5 gm.	....
Total pounds	100	100	100

[a] Contributed the following per lb. of feed: 62.5 mg. $FeSO_4 \cdot 7H_2O$; 7.5 mg. $CuSO_4 \cdot 5H_2O$; 25 mg. ZnO; 15.5 mg. $MnSO_4 \cdot H_2O$; 0.5 mg. $CoSO_4 \cdot 7H_2O$; 0.15 mg. KI; 115.9 mg. NaCl.

[b] One pound of this supplement furnished 0.5 gm. of chlortetracycline.

[c] Contributed the following per lb. of feed: 10 mg. aureomycin; 1 mg. riboflavin; 4½ mg. calcium pantothenate; 5 mg. niacin; 64 mg. choline chloride; 7½ micrograms vitamin B_{12}; 300 units vitamin D_3.

by Lyman *et al.* 1953 and by Chang, *et al.* (1955). In the present investigation, the nitrogen solubility of the low-protein quality cottonseed meal was only 18.20% as compared to 57.85% for the better meal.

Results and Discussion

The results of the effect of lysine on growth rate and feed efficiency are summarized in table 3 for test 1. The pigs in all groups receiving the ration containing added lysine made significantly greater ($P<.01$) daily gains on both the low-quality and the high-quality cottonseed meal. The difference in feed efficiency was significant ($P<.01$) for the lysine-fed pigs as compared to the control group (without lysine added). At the end of the 98-day test the pigs in the control group I were given the ration containing 0.62% lysine. The daily gain increased immediately as shown in figure 1. That the lysine added to these grain sorghum-cottonseed meal rations was the factor responsible for greater growth rate was shown by the response of the control pigs in group I, test 1, when they received the ration containing the added lysine.

TABLE 2. CHEMICAL CHARACTERISTICS OF COTTONSEED MEALS USED IN SWINE FEEDING TESTS

Chemical characteristic	Experiment I Cottonseed meal, low protein quality	Experiment I Cottonseed meal, high protein quality	Experiment II
Total gossypol, %	1.15	0.84	0.98
Free gossypol, %	0.03	0.02	0.03
Protein content, %	40.12	40.18	41.18
Total lysine (microbiological),			
Percent of sample	1.75	1.81	1.83
Percent of protein	4.36	4.50	4.45
Lysine with free epsilon amino groups,			
Percent of sample	0.80	1.20	1.13
Percent of protein	1.99	2.99	2.71
Nitrogen solubility, %	18.2	57.9	62.2

TABLE 3. EFFECT OF LYSINE SUPPLEMENTATION WITH COTTONSEED MEALS OF HIGH AND LOW PROTEIN QUALITY (EXPERIMENT I)
98-day test (June 18–September 24, 1959)

Group	Pigs fed in individual pens rations—self fed [a]	Av. daily gain	Feed/100 lb. gain
		lb.	lb.
I	Low quality cottonseed meal; no lysine added	0.34	588.0
II	Low quality cottonseed meal +1.42% lysine preparation (0.31% lysine)	1.66	344.2
III	Low quality cottonseed meal +2.84% lysine preparation (0.62% lysine)	1.74	340.4
IV	Low quality cottonseed meal + 0.3% synthetic l-lysine·HCl (0.25% lysine)	1.33	332.0
V	High protein quality cottonseed meal; no lysine added	1.07	370.0
VI	High protein quality cottonseed meal +1.42% lysine preparation (0.31% lysine)	1.61	349.4
VII	High protein quality cottonseed meal +2.84% lysine preparation (0.62% lysine)	1.71	343.0
VIII	High protein quality cottonseed meal +0.3% synthetic l-lysine·HCl (0.25% lysine)	1.49	341.0

[a] Each group started with 8 pigs. In group II, 1 pig and in group IV, 2 pigs were removed due to enteritis, and general unthriftiness.

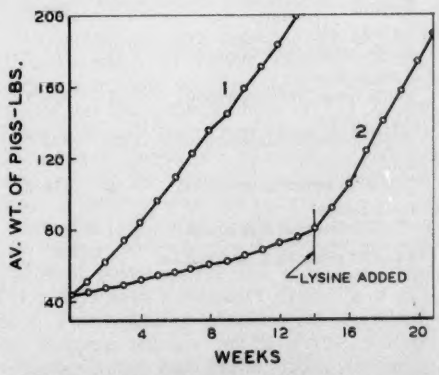

Figure 1. The effect of adding lysine to the ration after 98 days: (1) low quality cottonseed meal with 0.62% lysine added at the beginning of the experiment (Group III). (2) low quality cottonseed meal (Group I) with 0.62% lysine added after 98 days.

The group of pigs receiving the ration containing the high-quality cottonseed meal without the added lysine gained 1.07 lb. per day as compared to a gain of only 0.34 lb. daily for the pigs fed the ration containing the low-quality cottonseed meal without the added lysine.

In the second test the cottonseed meal-grain sorghum rations with the added lysine when fed to 57-lb. pigs resulted in greater gain and more efficient gains when compared to the control ration. The pigs receiving 0.5% added lysine gained 1.61 lb. per day as compared to a 1.32 lb. average daily gain for the control group, a significant difference ($P<.05$). The feed required per 100 lb. gain for the group receiving 0.5% added lysine was 356.9 as against 406.8 lb. for the control group (no added lysine), a significant difference ($P<.01$). The second test like the first test showed increased gains and more efficient feed utilization when lysine is added to a ration of sorghum grain and cottonseed meal. The results of the effect of the added lysine on gains and feed efficiency for the second test are summarized in table 4.

TABLE 4. EFFECT OF ADDING LYSINE TO SORGHUM GRAIN—COTTONSEED MEAL RATIONS FOR GROWING, FATTENING PIGS (EXPERIMENT II)
91-day test July 5, 1960—October 4, 1960

Group[a]	Av. daily gain	Feed/100 lb. gain
	lb.	lb.
1 Control	1.32	406.8
2 0.1% Lysine (0.5% lysine feed supplement)	1.42	363.9
3 0.2% Lysine (1.0% lysine feed supplement)	1.51	374.8
4 0.3% Lysine (1.5% lysine feed supplement)	1.56	376.7
5 0.4% Lysine (2.0% lysine feed supplement)	1.58	378.7
6 0.5% Lysine (2.5% lysine feed supplement)	1.61	356.9

[a] 8 pigs per group, fed in individual lots.

Summary

Lysine has been shown to increase gain and feed efficiency when added to a ration of sorghum grain and cottonseed meal for growing-fattening pigs.

Supplementing the rations with lysine increased feed consumption.

Supplementation with 0.3% lysine markedly increased growth and improved feed efficiency in both experiments. Amounts of lysine above 0.3% gave only small increments of growth rate.

Literature Cited

American Oil Chemists Society. 1957. Official and Tentative Methods. (2nd ed., 1950 with supplements through 1957.)

Baliga, B. P., M. E. Bayliss and C. M. Lyman. 1959. Determination of free lysine epislon-amino groups in cottonseed meals and preliminary studies on relation to protein quality. Arch. Biochem. Biophys. 84:1.

Baliga, B. P. and C. M. Lyman. 1957. Preliminary report on the nutritional significance of bound gassypol in cottonseed meal. J. Am. Oil Chem. Soc. 34:21.

Brinegar, M. J., H. H. Williams, F. H. Ferris, J. K. Loosli and L. A. Maynard. 1950. The lysine requirement for the growth of swine. J. Nutr. 42:129.

Chang, W. Y., J. R. Couch and C. M. Lyman. 1955. The nutritional value of press-solvent cottonseed meals. J. Am. Oil Chem. Soc. 32:103.

Kuiken, K. A. and C. M. Lyman. 1948. Availability of amino acids in some food. J. Nutr. 36:359.

Lyman, C. M., B. P. Baliga and M. W. Saly. 1959. Reactions of proteins with gossypol. Arch. Biochem. Biophys. 84:2.

Lyman, C. M., W. Y. Chang and J. R. Couch. 1953. Evaluation of protein quality in cottonseed meals by chick growth and by a chemical index method. J. Nutr. 49:679.

Lyman, C. M., K. A. Kuiken and F. Hale. 1956. Essential amino acid content of farm feeds. Tex. Agr. Exp. Sta. Tech. Art. 2382.

Mertz, E. T., D. C. Shelton and W. M. Beeson. 1949. The amino acid requirements of swine, lysine. J. Animal Sci. 8:524.

Pond, W., T. C. Hillier and R. W. MacVicar. 1953. Amino acid supplementation to corn and milo rations for growing pigs. J. Animal Sci. 12:928.

Shelton, D. C., W. M. Beeson and E. T. Mertz. 1951. Quantitative l-lysine requirement of the weanling pig. Arch. Biochem. 30:1.

SOME GENETIC ASPECTS OF GESTATION LENGTH, AND BIRTH AND WEANING WEIGHTS IN HEREFORD CATTLE [1]

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ESTIMATES of the heritabilities of and the genetic correlations among economically important traits are of value in formulating selection and mating plans for farm animals. The degree to which a trait is heritable indicates the amount of progress that one can expect to make by mass selection. Genetic correlations indicate whether or not genetic change in one trait is expected to accompany a genetic change in another.

In this study the influence of certain "non-genetic" factors on gestation length, birth weight and weaning weights of Hereford calves was determined. This information was then used to adjust the records so that a genetic analysis could be made of the data to obtain heritability estimates for these three traits as well as the genetic correlations among them.

Materials and Methods

Data used in this study were obtained from a herd of registered Herefords which were the property of the San Carlos Apache Indian Tribe of San Carlos, Arizona. The elevation of the reservation where the registered herd was maintained is about 4700 ft. and the rainfall averages about 14 in. annually. The heaviest rainfall usually occurs during the months of February, July, August and September. The year 1948, which provided the data from which this study was made, was drier than usual and the yearly rainfall was the lowest of a 20-year cycle. As a result, grazing conditions were poor and weaning weights were light.

Records were available on a total of 414 calves sired by eight different bulls. Three hundred and fifty-one calves were produced by artificial insemination and records were available on the length of gestation as well as birth and weaning weights. About 2 weeks before they were expected to calve, pregnant cows were rounded up and brought into a pasture of about two sections of level topography containing a small amount of brush. Herd attendants, equipped with portable scales, maintained a continuous watch over the herd of expectant cows from daylight until dark. When a new-born calf was found, it was promptly weighed, tattooed and all pertinent data concerning it and its dam were entered in record books. The calving season extended from February 7, to June 23, with most of the calves being born in February, March and April. All calves were weaned on November 10.

The length of the gestation period, in days, was computed from the recorded date of insemination and the date of birth. Birth weights were recorded to the nearest pound within 24 hours of the time of birth. Weaning weights were adjusted to a 210-day basis by calculating the actual daily gain from birth to weaning, multiplying this by 210 and adding the birth weight.

Results and Discussion

Although data were available for all three traits in only 351 calves, factors affecting birth weights and weaning weights were calculated on the entire sample of 414 calves. These included those from cows which were pasture-bred during the same period as the cows which were bred artificially but the date of breeding was not recorded.

Sex. The sex ratio in all 414 calves was 119 males per 100 females. The average length of gestation for the 351 calves was 287.0 days with a standard deviation of 6.1 days. This length of gestation was very similar to figures reported for Herefords by other workers (Burris and Blunn, 1952; Gerlaugh *et al.*, 1951; Wheat and Riggs, 1952; Livesay and Bee, 1945; Rife *et al.*, 1943). Bull calves were carried *in utero* an average of 0.8 days longer than heifer calves but this difference was not significant. Other workers

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have also made similar observations (Knapp et al., 1940; Livesay and Bee, 1945; Burris and Blunn, 1952; Wheat and Riggs, 1952).

The average birth weight of 414 calves was 71.9 lb. with a standard deviation of 8.3 lbs. Bull calves weighed an average of 2.5 lb. more than heifers ($P<.01$). This was somewhat less than the average sex difference of 5.2 lb. found by Koch *et al.* (1959) in a study of the records of 2,946 calves of various breeds from six different stations. Birth weights of heifer calves were adjusted to a bull calf basis by multiplying their birth weights by the factor 1.0363 rather than adding the difference in the birth weights of the two sexes.

The average 210-day weaning weights of 414 calves was 359.7 lb. with a standard deviation of 51.9 lb. Bull calves weighed an average of 26.4 lb. more than heifer calves at weaning ($P<.01$), and a multiplicative adjustment factor of 1.0765 was used to adjust weaning weights of heifers to a bull calf basis. Other workers have also reported that bull calves are heavier than heifer calves at weaning (Koch and Clark, 1955; Rollins and Guilbert, 1954; Koger and Knox, 1945).

Age of Dam. The dams of the calves in this study ranged in age from 2 to 8 years. Age of dam had no significant influence on the length of gestation although it did have a significant influence ($P<.01$) on birth and weaning weights. The data on birth weights were adjusted to a 6-year old dam basis and weaning weights to a 6 and 7-year old dam basis. Multiplicative adjustment factors were used and these were derived by fitting a curved line to the means for the different age groups by means of the formula for a second degree parabola. The ages of the cows, when their calve's weights were highest, were determined from these curves and all records were adjusted to this age group. Adjustment factors determined in this way were comparable to those used by other experiment station workers.

Date of Birth. The length of gestation, birth weight and weaning weight for all calves were grouped into 2-week periods through the calving season to determine if the date the calves were born was a significant source of variation in these traits. Length of gestation was not significantly different for calves born at different times during the calving season. Time of birth did have a significant ($P<.01$) effect on both birth weights and weaning weights. The heaviest calves at birth were born during the period from March 1 to 15, whereas calves born during the period from February 16 to 29, had the heaviest adjusted weaning weights and calf weights were adjusted to these particular dates. All eight sires were used more or less at random on the group of cows although some sired more calves than others. To avoid any possibility of confounding sire and time of birth effects, adjustment factors were calculated for calves from each sire by fitting a curved line to the data as described for the entire group. The adjustment factors needed to adjust the data to the desired date were determined from the smoothed line.

Genetic Correlations and Heritability Estimates. After the data were adjusted for the appropriate factors, discussed previously, they were analyzed by the method described by Hazel *et al.* (1943) for swine and adapted to beef cattle by Knapp and Clark (1947). Standard errors of the heritability estimates were obtained according to the method of Hazel and Terrill (1945). Standard errors of the genetic correlations were computed from the formula reported by Robertson (1959).

The mean squares and cross products from the analysis of variance and covariance for length of gestation, birth weights and weaning weights are shown in table 1. Differences between sire groups were highly significant ($P<.005$) for gestation length and birth weight but not significant for weaning weights ($P<.10$).

TABLE 1. MEAN SQUARES AND CROSS PRODUCTS FROM THE ANALYSIS OF VARIANCE AND COVARIANCE FOR LENGTH OF GESTATION (g), BIRTH WEIGHTS (b) AND WEANING WEIGHTS (w)

		Mean square			Covariance		
Source of variation	d.f.	G	B	W	GB	GW	BW
Total	350	.....	.....	....	.....	.....	.....
Between sires	7[a]	220.00**	578.70**	4456	140.29	281.14	1100.43
Within sires	343	33.80	70.90	2262	6.57	19.81	56.46

[a] k=35.41.
** P<.005.

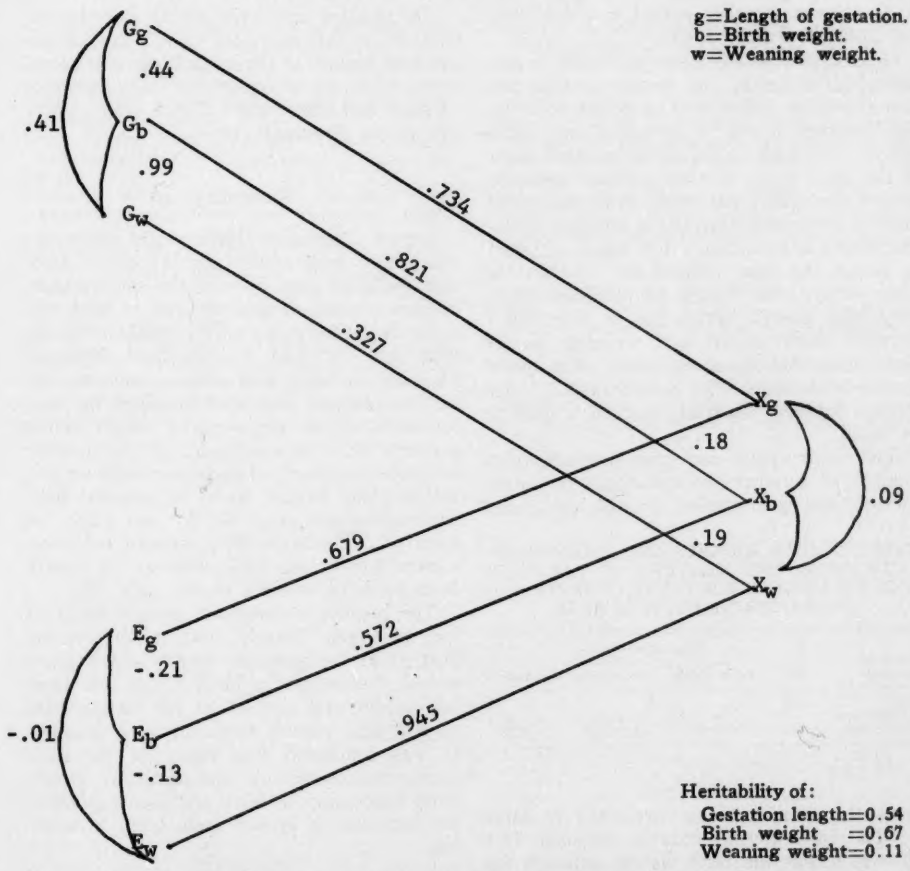

Figure 1. Path-coefficient diagram showing the genetic (G) and environmental (E) influences on gestation length (g), birth weight (b) and weaning weight (w).

The path-coefficient diagram showing the genetic and environmental influences on gestation length, birth weight and weaning weight is presented in figure 1. Heritability estimates for the three traits studied were obtained by squaring the path-coefficients. Length of gestation was $54\pm28\%$, birth weight $67\pm32\%$ and weaning weight $11\pm11\%$ heritable. The high heritability estimate for length of gestation is similar to that reported by Wheat *et al.* (1959). The high heritability estimate for gestation length indicates that this trait is affected considerably by additive gene action, an observation borne out by the results of Gerlaugh *et al.* (1951). These workers found that the gestation period of purebred Hereford calves was 10 days longer than that for purebred Angus calves, but the crossbred calves from the reciprocal crosses of these two breeds had an intermediate length of gestation, indicating largely additive gene action with very little heterosis involved. Similar conclusions were reached by McDowell *et al.* (1959) in a study of crosses of Red Sindhi and Jerseys. They found that each 25% of Sindhi inheritance increased gestation length approximately three days, suggesting additive genetic effects.

The heritability of birth weight of $67\pm28\%$ was higher than most figures reported in the literature whereas the heritability of weaning weight was lower. The heritability of birth weight in beef cattle averages about

40% whereas weaning weight is about 30% heritable (Warwick, 1958).

Genetic correlations between length of gestation, birth weight and weaning weight are also shown in figure 1. The genetic correlation between length of gestation and birth weight was 0.44 ± 0.28 indicating that some of the same genes causing a longer gestation period also caused the calves to be heavier at birth. The genetic correlation between gestation length and weaning weight was 0.41 ± 0.42 or about the same magnitude as that for birth weight and length of gestation. The very high genetic correlation of 0.99 ± 0.01 between birth weight and weaning weight also shows that the same genes seem to influence both traits. The environmental correlations between the traits studied tended to be small.

The mean square and cross products from analysis of variance and covariance for intra-uterine and post-uterine growth calculated from the same data are presented in table 2. The intra-uterine growth averaged 74.4 lb. which was the birth weight adjusted for sex, age of dam and time of birth expressed on the basis of a standard 287-day gestation period. The intra-sire regression coefficient for birth weight on gestation length of 0.19 was used to adjust to this standard gestation length. Post-uterine gains were 301.0 lb. and were the average total gains made from birth to weaning or for a period of 210 days.

TABLE 2. MEAN SQUARES AND CROSS PRODUCTS FROM THE ANALYSIS OF VARIANCE AND COVARIANCE FOR INTRA-UTERINE AND POST-UTERINE GROWTH RATE

Source of variation	d.f.	Mean square		
		Intra-uterine	Post-uterine	Covariance
Total	350			
Between sires	7[a]	536.43 **	2755.86	470.43
Within sires	343	70.01	2215.15	3.18

[a] k=35.41.
** P<.005.

A very high genetic correlation of 0.93 ± 0.07 between intra-uterine and post-uterine growth illustrates again that many of the same genes affect growth rate of the calves before and after birth. The heritability estimate for intra-uterine gains was $63 \pm 31\%$ and for post-uterine gains it was $3 \pm 7\%$. These estimates are in keeping with the heritability estimates for birth weights and weaning weights in this study since they were calculated from the same data.

The positive and large genetic correlations obtained in this study for growth during two different periods of the calf's life are in agreement with other reports in the literature (Knapp and Clark, 1947; Urick *et al.*, 1957; Romo and Blackwell, 1954).

Summary

Length of gestation, birth weight and weaning weight were studied in 351 calves from eight different sires born in the same season. Neither sex, age of dam nor date of birth had a significant influence on the length of gestation, but all had a significant influence ($P<.01$) on birth and weaning weights. Adjustment factors were used to adjust the data for birth weight and weaning weight before a genetic analysis was made. The heritability estimates for length of gestation, birth weight, and weaning weight, based on paternal half-sib correlations, were 54, 67 and 11%, respectively. The heritability estimate for intra-uterine growth was 63%, whereas for growth from birth to weaning it was only 3%.

The genetic correlations were 0.44 ± 0.28 for gestation length and birth weight, 0.41 ± 0.42 for gestation length and weaning weight, 0.99 ± 0.01 for birth weight and weaning weight and 0.93 ± 0.07 for intra-uterine growth and growth from birth to weaning. It was concluded that many of the same genes responsible for variations in growth from conception to birth are also responsible for variation in growth from birth to weaning.

Literature Cited

Burris, M. J. and C. T. Blunn. 1952. Some factors affecting gestation length and birth weight of beef cattle. J. Animal Sci. 11:34.

Gerlaugh, P., L. E. Kunkle and D. C. Rife. 1951. Crossbreeding beef cattle. A comparison of the Hereford and Aberdeen-Angus breeds and their reciprocal crosses. Ohio Agr. Exp. Sta. Res. Bull. 703.

Hazel, L. N., M. L. Baker and C. F. Reinmiller. 1943. Genetic and environmental correlations between the growth rates of pigs at different ages. J. Animal Sci. 2:118.

Hazel, L. N. and C. E. Terrill. 1945. Heritability of weaning weight and staple length in range Rambouillet lambs. J. Animal Sci. 4:347.

Knapp, B., Jr. and R. T. Clark. 1947. Genetic and environmental correlations between growth rate of cattle at different ages. J. Animal Sci. 6:174.

Knapp, B., Jr., W. V. Lambert and W. H. Black. 1940. Factors influencing length of gestation and birth weight in cattle. J. Agr. Res. 61:277.

Koch, R. M. and R. T. Clark. 1955. Influence of sex,

season of birth and age of dam on economic traits in range beef cattle. J. Animal Sci. 14:386.
Koch, R. M., K. E. Gregory, J. E. Ingalls and R. L. Arthaud. 1959. Evaluating the influence of sex on birth weight and pre-weaning gain in beef cattle. J. Animal Sci. 18:738.
Koger, M. and J. H. Knox. 1945. The effect of sex on weaning weight of range calves. J. Animal Sci. 4:15.
Livesay, E. A. and U. G. Bee. 1945. A study of the gestation periods of five breeds of cattle. J. Animal Sci. 4:13.
McDowell, R. E., J. L. Fletcher and J. C. Johnson. 1959. Gestation length, birth weight and age at first calving of crossbred cattle with varying amounts of Red Sindhi and Jersey breeding. J. Animal Sci. 18:1430.
Rife, Q. C., P. Gerlaugh, L. Kunkle, G. W. Brandt and L. H. Snyder. 1943. Comparative lengths of gestation periods of Aberdeen-Angus and Hereford cows carrying purebred and crossbred calves. J. Animal Sci. 2:50.
Robertson, A. 1959. The sampling variance of the genetic correlation coefficient. Biometrics 15:469.
Rollins, W. C. and H. R. Guilbert. 1954. Factors affecting the growth of beef calves during the suckling period. J. Animal Sci. 13:517.
Romo, A. and R. L. Blackwell. 1954. Correlations between type and weight of range cattle at different periods. Proc. of Am. Soc. of An. Prod., Western Section. 5:205.
Urick, J. A., A. E. Flower, F. S. Willson and C. E. Shelby. 1957. A genetic study of steer progeny groups during successive growth periods. J. Animal. Sci. 16:217.
Warwick, E. J. 1958. Fifty years of progress in breeding beef cattle. J. Animal Sci. 17:922.
Wheat, J. D. and J. K. Riggs. 1952. Length of gestation period in beef cattle. J. Animal Sci. 43:99.
Wheat, J. D., J. K. Riggs and R. R. Shrode. 1959. A statistical study of relationship, inbreeding, gestation length, and calving interval in a herd of Aberdeen-Angus cattle. J. Animal Sci. 18:820.

PROCESSING COSTS, MARKET VALUES, AND CONSUMER ACCEPTANCE OF LIGHT AND NORMAL WEIGHT HOGS [1]

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MANY investigations have been conducted on the evaluation of live hogs and hog carcasses. Wallace *et al.* (1960a, 1960b), Robinson (1946), Hankins and Ellis (1945), Cole *et al.* (1953), Loeffel *et al.* (1943), Cummings and Winters (1951), Hetzer *et al.* (1956) and Smith (1957) reported that as body weight of hogs increased backfat increased, while yield of preferred cuts decreased.

Atkinson and Klein (1945, 1946), Tribble *et al.* (1956), Blunn and Baker (1947) and Menzies-Kitchin (1942) reported that the amount of feed required per 100 lb. gain increased as live weight increased.

Consumer studies by Birmingham *et al.* (1954) and Vrooman (1952) showed that there is an overwhelming preference for leaner cuts of pork. Mullins *et al.* (1960) studied the value of 160 and 220-lb. hogs. General consumer acceptability was good in both weight groups. However, the cuts from the heavier hogs were criticized for being too fat more often than cuts from the lighter hogs. The market value of a hog should depend not only on its weight but also on the relative proportions and prices of the different cuts and the cost of processing. Workers have not fully considered the packer and retailer in efforts to determine the optimum slaughter weight and there is only a limited amount of research concerning the consumer's viewpoint. The object of this research was to consider the feasibility of marketing lighter weight hogs considering the producer, packer, retailer and consumer.

Materials and Methods

Data from 216 Hampshire hogs raised as part of the Kentucky Hampshire Herd Improvement Project were analyzed in order to determine average daily gain and pounds of feed required per 100 lb. of gain. These hogs were fed in pairs, each pen containing one litter-mate barrow and gilt. Paired data using the "t" distribution were employed in determining significance of differences at 160 and 200 lb. live weight. The figures were projected to hogs weighing 220 lb. live weight in order to be able to estimate current feed costs of 160 and 220 lb. hogs.

Complete carcass data were obtained from 53 other hogs of Hampshire and Duroc breeding. The mean adjusted slaughter weight for 8 Durocs and 19 Hampshires was 160.2 lb. with a range of 145 to 172 lb. The mean adjusted slaughter weight of 8 Durocs and 18 Hampshires of like breeding was 223.6 lb. with a range of 210 to 240 lb. Live weight adjustment was made by using 12% of hot carcass weight (shipper style) as a standard and adding or subtracting from live weight as required (Ramsey and Kemp, 1958). Value per hundred lb. live weight and value per hundred lb. packer style dressed weight were determined for each hog. Fresh center chops, whole and sliced Boston butts, cured hams, cured picnics and sliced bacon from hogs of the weight groups listed were sold at the retail level. Consumers were contacted at the point of purchase and were asked by telephone after they had prepared and served the meat to evaluate the cuts for leanness, size, tenderness and palatability. A total of 561 consumer replies were received.

Center loin roasts from 8 light and 8 heavy Duroc carcasses and from 9 light and 8 heavy Hampshire carcasses were roasted at 325° F. to an internal temperature of 185° F. and served to a seven-member taste panel which judged flavor and tenderness. A hedonic scale as described by Peryam and Pilgrim [2] (1957) was used to evaluate flavor and tenderness. Objective tenderness was measured with a Warner-Bratzler shear using 2 one in. cores with 3 shears per core. Total cooking loss from each roast was recorded and the mean differences tested for statistical significance.

[1] The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published with approval of the Director.

[2] In order to facilitate statistical analysis, numerical values were substituted for descriptive terms as follows: 9, like extremely; 8, like very much; 7, like moderately; 6, like slightly; 5, neither like nor dislike; 4, dislike slightly; 3, dislike moderately; 2, dislike very much; 1, dislike extremely.

TABLE 1. ESTIMATED FEED COSTS OF PRODUCING 160 AND 220-POUND HOGS

Hog wt. range	Total feed required during interval	Feed per lb. of gain	Protein in feed	Cost per cwt. of feed	Total cost of feed
lb.	lb.	lb.	%	$	$
44–75	77.5	2.5	16	3.16	.....
75–125	170.0	3.4	14	3.10	.....
125–160	148.5	4.2	12	3.00	12.17
160–220	285.0	4.8	12	3.00	20.72

Twenty-five packers from 13 states replied to a questionnaire which was designed to have packers give their opinion on the merits of slaughtering hogs at 160 lb. live weight. A total of 73 retailers from 19 states listed the size of hams, loins, picnics and Boston butts they preferred to merchandise. Their replies were compared to replies of the packers whose questionnaire asked the size of primal cuts their customers preferred.

Statistical analyses included the t-distribution as described by Snedecor (1956). This was used for all significance tests with the exception of the consumer acceptance data in which case standard error of the difference between two proportions in two different frequency distributions was used as described by Pearson and Bennett (1942).

Results and Discussion

Feed required per hundred lb. gain averaged 342.6 lb. for the 160-lb. hogs and 366.9 lb. for the 200-lb. hogs. Data for the 108 pairs of litter-mates indicated that the mean difference of 24.3 ± 4.2 lb. of feed consumed was significant ($P < 0.01$). The figures were projected from hogs weighing 200 lb. to those weighing 220 lb. The estimated feed cost of these 220 lb. hogs was compared to the feed cost of hogs weighing 160 lb. (table 1).

Average daily gain from weaning increased throughout the feeding period but at a decreasing rate after the hogs reached 100 lb. Average daily gain from weaning for the 160 to 200-lb. hogs was 1.52 and 1.55 lb., respectively. Statistical analysis, using paired data, showed that the difference between growth rate of 160 lb. hogs and 220 lb. hogs, though small, was significant ($P < 0.01$). This was because with few exceptions, all hogs made this small increase in average daily gain. This work agrees with that of Atkinson and Klein (1945). However, they further stated that the average daily gain reached a maximum at about 200 to 210 lb. and then gradually declined until at 300 lb. it was 10% less than it was at 200 lb.

Table 2 shows the percent of packers preferring the various weight ranges of hogs. Eighty-three percent of the packers replying stated that they preferred hogs weighing 200 to 225 lb. They estimated that processing costs were 20% greater per unit weight for hogs weighing under 175 lb. Because of this higher processing cost, packers paid an average of $1.50 per hundred lb. less for hogs weighing under 175 lb. Reasons for the greater processing costs included the following: (a) "It takes practically the same time and facilities to dress, chill and cut the light weight hog as it does a hog which yields twice as many lb. of pork", (b) "Lesser value of the thin bellies from light hogs", and (c) "The yield of the lighter hogs is less."

Table 3 shows partial results of the retailer questionnaire. These replies were converted to percent and compared to replies of the packers whose questionnaire included a question concerning the size of primal cuts their customers preferred.

Packers and retailers were not entirely in agreement on the question of sizes. Retailers in general preferred smaller hams, loins, pic-

TABLE 2. PERCENT OF PACKERS PREFERRING VARIOUS WEIGHT RANGES OF HOGS

Weight range, lb.	Order of preference				
	First	Second	Third	Fourth	Fifth
Under 175	0	0	0	25.0	75.0
175–200	0	22.2	38.9	43.8	0
200–225	82.6	11.1	5.6	0	0
225–250	13.0	66.7	22.2	0	0
Over 250	4.4	0	33.3	31.2	25.0

TABLE 3. PACKER AND RETAILER PREFERENCES FOR DIFFERENT WEIGHT CUTS

Cuts, lb.	Packers	Retailers
	% preferring	
Hams		
Under 11	6.8	13.3
11–13	31.9	46.7
13–15	37.9	30.7
15–17	20.1	9.3
No preference	3.1	1.3
Loins		
Under 10	13.2	4.0
10–12	47.4	69.3
12–14	29.8	26.7
14–16	6.5	2.7
Above 16	2.9	0
No preference	0.2	0
Picnics		
Under 4	0.7	0
4–6	42.7	90.4
6–8	51.0	12.3
Above 8	3.5	0
No preference	2.1	0
Butts		
Under 3	2.5	5.5
3–5	48.0	67.1
5–7	37.0	35.6
Above 7	5.2	0
No preference	2.6	0

nics, and Boston butts than they are now buying. Reasons for preferring lighter cuts included: (a) customer acceptance, (b) balanced movement of retail cuts, (c) profit cutout, (d) more flavor and tenderness, (e) consistently leaner, and (f) more attractive unit cost.

A summary of the results of the consumer survey is given in table 4. Consumers indicated that a higher percent of the hams, picnics, bacon, center chops and Boston butts from the heavier hogs were too fat. These differences were highly significant ($P<0.01$) with the exception of center chops which approached significance. Another difference mentioned was the size of cut. Whole hams and center chops from the heavier hogs were listed as too large by 31.6 and 9.0% of the consumers, respectively. Only 11.9 and 1.3%, respectively, of the whole hams and center chops from the lighter hogs were listed as too large. These differences also were significant ($P<0.01$). Consumers found no significant differences in tenderness of cuts from the 160 and 200-lb. hogs. They found the flavor of all cuts from hogs of both weight groups very acceptable.

Panel palatability and tenderness tests showed no significant difference between groups. The average flavor values were 7.62 and 7.60 and the tenderness values were 7.67 and 7.62 for loins from hogs weighing 160 and 220 lb., respectively. The average Warner-Bratzler shear scores, in lb., were 11.98 and 10.78 for the light and heavy hogs, respectively.

Cooking shrinkage for 17 center loin roasts from 160 lb. hogs and for 16 center loin roasts from 220 lb. hogs was 23.1 and 25.3 percent respectively. The 2.2 percentage points less cooking shrinkage for loins from the lighter hogs was significant ($P<0.01$) and probably was due to increased rendering of fat.

TABLE 4. SUMMARY OF CONSUMER SURVEY

Weight group	No. of replies	Leanness			Size		
		Too lean	About right	Too fat	Too small	About right	Too large
		%	%	%	%	%	%
Hams							
Heavy	38	2.6	78.9	18.4**	0	68.4	31.6*
Light	42	0	97.6	2.4	2.4	85.7	11.9
Picnics							
Heavy	38	0	71.0	28.0**	2.6	92.1	5.3
Light	38	2.6	89.5	7.9	7.9	89.5	2.6
Bacon							
Heavy	78	5.1	78.2	16.7**	5.1	93.6	1.3
Light	78	6.4	88.5	5.0	12.8	87.2	0
Center chops							
Heavy	100	4.0	82.0	14.0*	2.0	89.0	9.0*
Light	78	1.3	92.3	6.4	6.4	92.3	1.3
Boston butts							
Heavy	29	0	72.4	27.6**	0	100.0	0
Light	42	0	90.5	9.5	2.4	97.6	0

* Difference significant between heavy and light ($P<0.05$).
** Difference significant between heavy and light ($P<0.01$).

TABLE 5. AVERAGE WEIGHT AND PERCENT LIVE WEIGHT OF CUTS FROM 160 AND 220 POUND HOGS

Cut	Light (27 hogs)		Heavy (26 hogs)	
	Wt. lb.	% Packer wt.	Wt. lb.	% Packer wt.
Skinned hams	12.15	21.32	16.22	20.22
Loins	9.72	17.06	13.45	16.76
Picnics	5.73	10.06	7.88	9.81
Boston butts	3.81	6.68	5.36	6.68
Bellies	8.08	14.19	11.41	14.22
Total lard stock	17.16	15.04	29.58	18.35

TABLE 7. SUMMARY OF STATISTICS FOR COMPARISON OF VALUE PER HUNDRED POUNDS PACKER WEIGHT OF 160 AND 220 POUND HOGS

Weight	Number of hogs	Degrees of freedom	Mean value per cwt.	Sum of Squares
lb.			$	
160	27	26	27.43	21.17
220	26	25	26.16	28.26
		Sum 51	Difference 1.27**	Sum 49.43

** ($P<0.01$).

Tables 5 and 6 show the average carcass data for the two groups. Both groups were meaty hogs as noted by length, backfat, loin eye area and yield of lean cuts. Although the heavier hogs dressed slightly higher the differences were not significant. The lighter hogs produced significantly ($P<0.05$) more lean cuts, ham, loin, picnic, Boston butt, and more primal cuts, ham, loin, picnic, Boston butt and belly. This difference in yield of cuts, when converted to a monetary value using the average 1959 wholesale Chicago Provisioner prices showed the light hogs to be worth $1.27 more per 100 lb. packer style carcass weight. This difference was significant ($P<0.05$), table 7. This extra value of these well-muscled light hogs offsets the added packer cost of processing them.

lb. However, the heavier hogs made the faster gains. Packers estimated that procsesing costs were 20% greater for hogs slaughtered under 175 lb. Retailers in general preferred smaller cuts than they were buying. Significantly more consumers considered cuts from the heavier hogs too fat. No differences in tenderness were shown by the Warner-Bratzler shear machine or the taste panel. There was no significant difference in flavor of pork from the two weight groups. Cooking losses in loin roasts from the 220 lb. hogs were significantly higher. Processing costs were higher for light weight hogs, but total wholesale value per hundred lb. live weight was greater for the light weight hogs, thereby offsetting the extra processing costs.

TABLE 6. MEAN CARCASS MEASUREMENTS AND YIELD PERCENTS FOR HOGS WEIGHING APPROXIMATELY 160 AND 220 POUNDS

Item	Weight of hogs			
	Light (27 hogs)		Heavy (26 hogs)	
	Range	Mean	Range	Mean
	lb.	lb.	lb.	lb.
Adjusted live weight	145 –172	160.2	210 –240	223.6
Dressing percent (shipper)	77.3– 80.9	78.9	78.2– 82.9	79.4
Dressing percent (packer)	69.5– 72.7	71.1	68.3– 75.1	71.8
Length (inches)	26.3– 28.7	27.6	28.9– 31.0	29.8
Average backfat thickness (inches)	0.9– 1.4	1.14	1.2– 2.0	1.52
Area of eye 10th rib (square inches)	3.0– 4.5	3.61	3.6– 6.0	4.39
Percent lean cuts (packer)	51.8– 59.0	55.15	45.5– 57.7	53.57*
Percent primal cuts (packer)	68.3– 72.4	69.36	62.6– 72.4	67.75*

* Difference significant ($P<0.05$).

Summary

This study evaluated growth, feed conversion, carcass data, consumer acceptance, palatability factors, and packer and retailer opinions of light weight hogs.

Hogs weighing 160 lb. required significantly less feed per hundred lb. of gain at a lower price per lb. of gain than hogs weighing 220

Literature Cited

Atkinson, J. Jay and J. W. Klein. 1945. Feed consumption and marketing weight of hogs. U.S.D.A. Tech. Bul. 894.

Atkinson, J. Jay and J. W. Klein. 1946. Feed consumption and the production of pork and lard. U.S.D.A. Tech. Bul. 917.

Birmingham, E., D. E. Brady, S. M. Hunter, J. C. Grady and E. R. Kiehl. 1954. Fatness of pork in relation to consumer preference. Mo. Agr. Exp. Sta. Res. Bul. 549.

Blunn, C. T. and M. L. Baker. 1947. The relation

between average daily gain and some carcass measurements. J. Animal Sci. 6:424.

Cole, J. W., C. E. Riley, H. J. Smith and C. S. Hobbs. 1953. The effect of type and weight on the yield of primal and miscellaneous pork cuts. J. Animal Sci. 12:900.

Cummings, J. N. and L. M. Winters. 1951. A study of factors related to carcass yields in swine. Minn. Agr. Exp. Sta. Tech. Bul. 195.

Hankins, O. G. and N. R. Ellis. 1945. Composition and nutritive value of pork as related to weights of animals and cuts. U.S.D.A. Circ. No. 731.

Hetzer, N. O., J. H. Zeller and O. G. Hankins. 1956. Carcass yields as related to live hog probes at various weights and locations. J. Animal Sci. 15:257.

Loeffel, W. J., W. W. Derrick and M. Peters. 1943. Weight of pigs as it affects gains and carcass qualities. Neb. Agr. Exp. Sta. Bul. 351.

Menzies-Kitchin, A. W. 1942. Meat for meal return in pigs. J. Ministry of Agr. 49:174.

Mullins, A. M., R. F. Boulware, D. M. Thrasher, G. L. Robertson and E. Guillot. 1960. Lean hogs outweigh fat hogs in value. La. Agr. 4:4.

Pearson, F. A. and N. R. Bennett. 1942. Statistical Methods. John Wiley and Sons, New York, New York.

Peryam, D. R. and F. J. Pilgrim. 1957. Hedonic scale method of measuring food preferences. Food Tech. 11:9.

Ramsey, C. B. and J. D. Kemp. 1958. Factors affecting viscera weights of hogs. Annual Livestock Field Day Report. Ky. Agr. Exp. Sta.

Robinson, W. L. 1946. The influence of the rate of fat deposition on the firmness of the fat of hogs. Ohio Agr. Exp. Sta. Bul. 664.

Smith, D. M. 1957. The relationship between liveweight and carcass-weight increments of pigs. New Zealand J. Sci. and Tech. 38(A):803.

Snedecor, G. W. 1956. Statistical Methods (5th ed.). Iowa College Press, Ames, Iowa.

Tribble, L. F., S. E. Zobrisky, W. H. Pfander, J. L. Lasley and D. E. Brady. 1956. Factors affecting growth, feed efficiency and carcass quality in swine. Mo. Agr. Exp. Sta. Res. Bul. 609.

Vrooman, C. W. 1952. Consumer report on pork products. Ore. State College, Sta. Bul. 521.

Wallace, H. D., G. E. McCabe, A. Z. Palmer, J. W. Carpenter, M. Koger and G. E. Combs. 1960a. The influence of slaughter weight on economy of production and carcass value of swine. Fla. Agr. Exp. Sta., An. Husb. and Nutr. Mimeo. Series No. 60–12.

Wallace, H. D., G. E. McCabe, A. Z. Palmer, J. W. Carpenter, M. Koger and G. E. Combs. 1960b. Feedlot performance and carcass traits of growing-finishing swine as influenced by sex and breed. Fla. Agr. Exp. Sta., An. Husb. and Nutr. Mimeo. Series No. 60–13.

PARENTERAL IRON ADMINISTRATION TO SOWS DURING GESTATION OR LACTATION [1]

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THE intramuscular injection of iron preparations into baby pigs for anemia prevention has become an accepted practice. Iron dextran given during the suckling period, either intramuscularly (Barber *et al.*, 1955; Brownlie, 1955; McDonald *et al.*, 1955; Kernkamp, 1957; Ullrey *et al.*, 1959; Rydberg *et al.*, 1959a; Zimmerman *et al.*, 1959; Meade *et al.*, 1959; Doornenbal, 1959; Maner *et al.*, 1959) or intraperitoneally (Zimmerman *et al.*, 1960) and iron dextrin given intramuscularly (Linkenheimer *et al.*, 1960) have been used successfully in maintaining a normal blood hemoglobin level. Other iron preparations, including peptonized iron (Wahlstrom and Juhl, 1960; Becker *et al.*, 1960), ferric ammonium citrate (Becker *et al.*, 1960; Doornenbal, 1959) or ferric phosphate (Barber *et al.*, 1955; Brownlie, 1955), have produced generally inferior results. Ferric ammonium citrate or ferric phosphate produced toxic symptoms.

Evidence has been reported for placental transfer of injected iron in swine (Rydberg *et al.*, 1959b) and in rabbits (Bothwell *et al.*, 1958). Earlier work demonstrated that the level of iron in the ration of lactating goats and cows (Elvehjem *et al.*, 1927) and swine (Hamilton *et al.*, 1930; Venn *et al.*, 1947) has no appreciable effect on the iron content of the milk.

This study was conducted to determine whether the transfer of iron injected intramuscularly into the sow during gestation or lactation is sufficient to prevent anemia in the offspring either through an increase in iron transport across the placenta or into the milk.

Experimental Procedure

Berkshire and Yorkshire sows were injected on the 100th day of gestation or on the sixth to ninth day of lactation with an iron-dextran complex.[3] The amount of iron administered was either 0, 2 or 10 mg. per pound of body weight.

Pigs, from sows treated during gestation, had blood drawn from the anterior *vena cava* at weekly intervals beginning at 3 or 10 days of age, ending at 17 or 31–33 days of age Hemoglobin was determined by the method of Sanford and Sheard (1929).

Litters, from two of five sows injected with iron on the 100th day of gestation and those from two untreated sows, were assigned at 10 days of age according to hemoglobin levels to the following treatments: (1) 200 mg. of iron from ferric oxide; (2) 400 mg. of iron from ferric oxide; (3) 200 mg. of iron from ferrous sulfate; (4) 400 mg. of iron from ferrous sulfate; (5) 150 mg. of iron from iron dextran given intramuscularly; and (6) negative control. Treatments 1 to 4 were given orally by stomach tube. Hemoglobin of each pig was recorded at the time of treatment and on days 9, 16 and 23 following treatment.

In the seven sows treated during lactation, milk samples were collected by manual expression into clean glass bottles immediately before and 1 and/or 6 and 24 hours following the injection of iron. Milk letdown was induced by the injection of 1.0 ml. of pitocin [4] into an ear vein. The pigs were allowed to nurse before milk was collected following iron administration. The iron content of the milk was determined as described by McDowell (1947).

Sows were kept in pasture lots with outside shelters during gestation and were brought into the concrete farrowing quarters just before farrowing where they remained with their litters until weaning. They were fed a corn-soybean oil meal-alfalfa meal-type gestation and lactation ration.

Results and Discussion

The hemoglobin response of pigs treated orally with iron along with that of their littermates given no iron or intramuscular iron is shown in figure 1. It will be noted that the

[1] Acknowledgement is made to R. R. Whipple for his technical assistance in this work.

[2] Animal Husbandry Department.

[3] Armidexan generously supplied through the courtesy of M. E. Davenport, Armour Pharmaceutical Co., Kankakee, Illinois.

[4] Armour purified oxytocic principle, 20 U.S.P. units/ml.

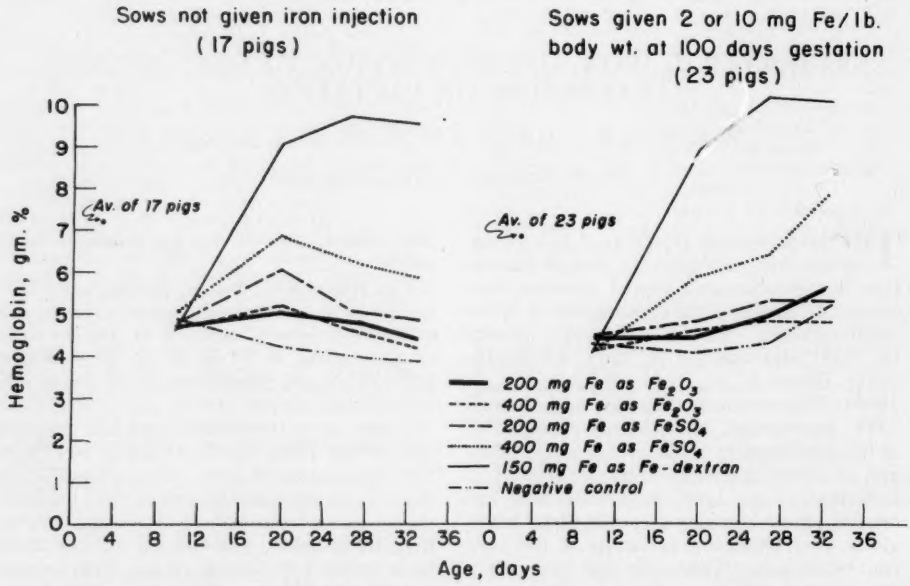
Sows not given iron injection
(17 pigs)
Sows given 2 or 10 mg Fe/lb.
body wt. at 100 days gestation
(23 pigs)
Hemoglobin, gm. %
Av. of 17 pigs
Av. of 23 pigs
200 mg Fe as Fe_2O_3
400 mg Fe as Fe_2O_3
200 mg Fe as $FeSO_4$
400 mg Fe as $FeSO_4$
150 mg Fe as Fe-dextran
Negative control
Age, days

Figure 1. Effect of iron administration to the sow during gestation or to the suckling pigs on blood hemoglobin level of the pigs.

hemoglobin levels at 10 days of age of pigs from sows injected with iron at 100 days gestation were not significantly different from those of pigs from untreated sows. Injected iron resulted in greater hemoglobin synthesis than oral iron. There was a higher hemoglobin level ($P<0.05$) in pigs given 400 mg. of ferrous iron than in those given either 200 or 400 mg. of ferric iron or 200 mg. of ferrous iron.

Table 1 summarizes the hemoglobin response of pigs as a function of the level of iron given the sow during gestation. There was no significant effect of iron administration to the sow on hemoglobin response of the pigs. The average hemoglobin at 31–33 days of age of pigs from sows treated with 0, 2 or 10 mg. of iron per pound of body weight were 5.92, 4.19 and 5.51 gm/100 ml., respectively. There was a marked response during the first week after the injection of 150 mg. of iron into the pigs from these sows (av. hemoglobin of 8.77 gm. % for those injected vs. 5.28 gm. % for those not injected).

TABLE 1. EFFECT OF LEVEL OF IRON GIVEN DURING GESTATION ON HEMOGLOBIN RESPONSE OF PIGS

	Level of iron given sow (mg. per lb. body weight)					
	0		2		10	
Iron given pigs at 10 days, mg.	0	150	0	150	0	150
No. of pigs[a]	26	3	25[b]	2	16[c]	2
Age of pigs, da.	Hemoglobin of pigs (gm. per 100 ml.)					
7	5.43	4.24	4.72	4.73	4.93	4.61
10	....	....	6.94	....	5.95	....
17	4.86	9.02	5.13	8.75	6.23	8.44
24	5.30	10.33	4.67	8.93	5.96	10.56
31–33	5.92	10.21	4.19	9.83	5.51	9.39

[a] The Hb values represented in figure 1 are included in these means.
[b] 10 pigs bled at 7 days and 15 pigs at 10 days of age.
[c] 10 pigs bled at 7 days and 6 pigs at 10 days of age.

Table 2 shows the iron content of the milk taken from sows before and at intervals after the intramuscular injection of iron. These values are somewhat higher than those reported by Venn *et al.* (1947) who obtained values ranging from 1.4–2.4 mg/l. The reasons for the considerable variation among sows and between samples are not apparent. There was no significant difference in the iron content of the milk before injection and at 1, 6 or 24 hours after injection. The average value for all treatments was 3.1 mg. of iron per liter (range 1.5–7.0 mg/l.). Based on an assumed average daily milk intake of one liter per pig, the iron content of the milk would have to reach 10–15 mg/l to meet the estimated oral iron requirement. This indication of insufficient mammary transfer of iron is substantiated by

TABLE 2. EFFECT OF INTRAMUSCULAR IRON INJECTION ON IRON CONTENT OF SOW'S MILK

Amount of iron given	No. of sows	Time milk sample taken			
			After injection, hr.		
		Before	1	6	24
mg./lb. of body wt.		mg./liter	mg./liter	mg./liter	mg./liter
0	4	3.0[a]	...	...	...
		2.0–5.0[b]	...	...	...
2	5	2.5	2.8	3.0	3.3
		1.5–6.5	2.3–4.0	3.0[c]	2.0–4.5
10	2	3.5	...	2.4	4.7
		2.5–4.5	...	2.0–2.8	2.3–7.0
Overall average		2.9	2.8	2.6	3.3

[a] Mean.
[b] Range.
[c] Only one sow.

the observed hemoglobin response of two litters whose dams were given 10 mg. of iron per pound of body weight intramuscularly on the 7th day of lactation. The average hemoglobin of these 12 pigs was 6.57 gm/100 ml. of blood at 7 days of age (before treatment of the sow), while one week after treatment (14 days of age) the average value was 6.09. Two weeks after treatment the four pigs left untreated had an average hemoglobin of 5.71 gm/100 ml., whereas that of the remaining eight pigs which were injected with 150 mg. of iron per pig at 14 days of age had responded with a hemoglobin increase to an average of 9.22 gm.

These data indicate that neither placental nor mammary transfer of iron injected into the sow during gestation or lactation is of sufficient magnitude to eliminate the necessity for treating the pigs individually with a source of iron during the suckling period to prevent anemia.

Summary

The intramuscular injection of 2 or 10 mg. of iron (supplied as iron-dextran) per pound of body weight into the sow on the 100th day of gestation or on the 6th to 9th day of lactation failed to prevent anemia in the pigs.

The oral administration of 400 mg. of ferrous iron produced higher ($P<0.01$) hemoglobin levels in anemic pigs than an equal quantity of ferric iron, but neither source at the levels given could be considered satisfactory.

Hemoglobin levels of anemic pigs were restored to normal within one week after the intramuscular injection of 150 mg. of iron supplied as iron-dextran.

The iron content of milk was not significantly affected by intramuscular injection into the sow of 2 or 10 mg. of iron per pound of body weight during lactation. The average value was 2.9 mg/l. before injection and 2.8, 2.6 and 3.3 at 1, 6 and 24 hours after injection, respectively.

Literature Cited

Barber, R. S., R. Braude and K. G. Mitchell. 1955. Studies on anemia in pigs. I. The provision of iron by intramuscular injection. Vet. Rec. 67:348.

Becker, D. E., R. M. Thomas, S. W. Terrill and A. H. Jensen. 1960. Sources of iron for the baby pig. AS–528 Mimeograph. Ill. Swine Grower's Day.

Bothwell, T. H., W. F. Pribilla, W. Mebust and C. A. Finch. 1958. Iron metabolism in the pregnant rabbit. Iron transport across the placenta. Am. J. Physiol. 193:615.

Brownlie, W. M. 1955. The treatment of piglet anemia. Vet. Rec. 67:350.

Doornenbal, H. 1959. The effect of certain oral and injectable iron preparations on the blood of baby pigs. Can. J. Animal Sci. 39:193.

Elvehjem, C. A., R. C. Herrin and E. B. Hart. 1927. Iron in nutrition. III. The effects of diet on the iron content of milk. J. Biol. Chem. 71:255.

Hamilton, T. S., G. E. Hunt, H. H. Mitchell and W. E. Carroll. 1930. The production and cure of nutritional anemia in suckling pigs. J. Agr. Res. 40:927.

Kernkamp, H. C. H. 1957. A parenteral hematinic for the control of iron-deficiency anemia in baby pigs. North Am. Vet. 38:6.

Linkenheimer, W. H., E. L. Patterson, R. A. Milstrey, J. A. Brockman and D. E. Johnson. 1960. Preparation and biological testing of a parenteral iron preparation. J. Animal Sci. 19:763.

Maner, J. H., W. G. Pond and R. S. Lowrey. 1959. Effect of method and level of iron administration on growth, hemoglobin and hematocrit of suckling pigs. J. Animal Sci. 18:1373.

McDonald, F. F., D. Dunlop and C. M. Bates. 1955. An effective treatment of anemia of piglets. Brit. Vet. Jour. 111:403.

McDowell, A. K. R. 1947. The estimation of copper and iron in cream, butter and dry butterfat. J. Dairy Res. 15:70.

Meade, R. J., H. C. H. Kernkamp, H. Windels and M. Dammann. 1959. The influence of amount and time of dosage of injectable iron and of "copperas" upon prevention of nutritional anemia in suckling pigs. H–168 mimeograph. University of Minn. 37th Annual Swine Field Day.

Rydberg, M. E., H. L. Self, T. Kowalczyk and R. H. Grummer. 1959a. The effectiveness of three different methods of iron administration to young pigs. J. Animal Sci. 18:410.

Rydberg, M. E., H. L. Self, T. Kowalczyk and R. H. Grummer. 1959b. The effect of pre-partum intramusclar iron treatment of dams on litter hemoglobin levels. J. Animal Sci. 18:415.

Sanford, H. and C. Sheard. 1929. A photoelectric hemoglobinometer. J. Lab. Clin. Med. 14:558.

Ullrey, D. E., E. R. Miller, D. R. West, D. A. Schmidt, R. W. Seerley, J. A. Hoefer and R. W. Luecke. 1959. Oral and parenteral administration of iron in the prevention and treatment of baby pig anemia. J. Animal Sci. 18:256.

Venn, J. A. J., R. A. McCance and E. M. Widdowson. 1947. Iron metabolism in piglet anemia. J. Comp. Path. and Therapeutics. 57:314.

Wahlstrom, R. C. and E. W. Juhl. 1960. A comparison of different methods of iron administration on rate of gain and hemoglobin level of the baby pig. J. Animal Sci. 19:183.

Zimmerman, D. R., V. C. Speer, V. W. Hays and D. V. Catron. 1959. Injectable iron-dextran and several oral iron treatments for the prevention of iron-deficiency anemia of baby pigs. J. Animal Sci. 18:1409.

Zimmerman, D. R., V. C. Speer, V. W. Hays and D. V. Catron. 1960. A comparison of intramuscular and intraperitoneal injection of iron-dextran. J. Animal Sci. 19:484.

FURTHER OBSERVATIONS ON THE PREVENTION OF PASTURE BLOAT BY THE USE OF ANTIBIOTICS IN ROTATION OR IN COMBINATION [1]

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THE concept of feeding antibiotics in rotation or in combination to prolong bloat prevention is relatively new. Johnson *et al.* (1960) found that erythromycin was effective for about 10 days following penicillin administration and that tylosin and chloramphenicol were effective after previous exposure of the animals to penicillin and erythromycin, respectively. This suggested the possible development of a rotation including penicillin, erythromycin, tylosin and chloramphenicol. Even though four such antibiotics fed sequentially may be effective, before the cycle can be repeated successfully the period of non-exposure to each single antibiotic must be long enough for "resistance" to subside. "Resistance" is defined herein as a partial or complete loss of effectiveness of an antibiotic preparation in the prophylaxis of bloat. Johnson *et al.* (1960) observed that withholding penicillin for periods of 14 and 17 days was not sufficient to permit return of effectiveness, while Mangan *et al.* (1959) reported that effectiveness was regained after 2 months. Johnson *et al.* (1958a) found that resistance to erythromycin could not be reversed by withholding it for periods of 26 days or less. Johnson *et al.* (1960) also found that feeding penicillin and erythromycin in combination controlled bloat for a much longer period than did feeding either antibiotic singly.

The present experiment was designed to attempt to develop rotations and combinations of antibiotics that provide continuous bloat control for a period of several months.

Experimental Procedure

Sixty-one dairy and beef animals were employed in the 1960 pasture bloat experiments. All animals grazed together on alfalfa pasture from 7 to 10 a.m. and from 3:30 to 6:30 p.m. A rotational grazing plan was followed on a 25-acre field of second-year alfalfa which was divided into 10 plots. As the season progressed a 19-acre field of first year alfalfa, divided into eight plots, was also used. Between grazing periods the animals were retained in a holding pen, near the pasture, where fresh water and trace-mineral salt were available.

The animals were ranked on the basis of body weight; then they were divided into successive blocks of four animals each, starting with the heaviest. Animals within each block were assigned randomly, one to each of four experimental groups. Group I was composed of 16 animals with an average initial weight of 553 lb. Groups II, III and IV were composed of 15 animals each with average initial weights of 590, 572 and 582 lb., respectively. Grain was fed at the average rate of 2 lb. per animal daily, usually just before the morning grazing. A group-feeding system was employed.

Table 1 shows the dates when various treatments were started and the average levels of antibiotics fed per animal per day. When antibiotics were given via drinking water, the daily dose was mixed each morning in approximately the volume of water that the group would drink in 24 hours. As discussed by Johnson *et al.* (1960), the order in which the antiboitics were administered (table 1) may have influenced the response. Carry-over effects other than "resistance" which had developed to a specific antibiotic, however, were not noted for periods greater than 3 days in length.

The evaluation of treatments was based on visual observation, using scores from 0 (no bloat) to 5 (terminal) as described by Johnson *et al.* (1958b). Bloat scores were recorded during each hour on pasture. The average daily maximum bloat severity" (ADM) is the sum of the daily maxima (highest value for each animal during the day) divided by number of animals in the group. It has been found

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TABLE 1. DATES WHEN TREATMENTS WERE INITIATED IN THE RESPECTIVE GROUPS AND LEVELS OF ANTIBIOTICS FED [a, b]

Date	Group I	Group II	Group III	Group IV
May 27	Control	P–35	P–20, E–35, T–35, C–50, and O–50	Control
June 3	.....	E–70	.....	.....
June 4	.....	.....	.....	Polymyxin
June 9	.....	.....	P–40, E–70, T–70, C–100 and O–100	.....
June 10	.....	T–70	.....	.....
June 12	.....	...	.....	Control
June 17	.....	C–140	.....	Miscellaneous [c]
June 24	.....	O–140	.....	.....
June 27	.....	.....	.....	P–35 water
July 1	.....	S–70	.....	.....
July 4	.....	.....	.....	E–70 water
July 8	.....	P–35	.....	.....
July 11	.....	.....	.....	T–70 water
July 15	.....	E–70	.....	.....
July 18	.....	.....	.....	C–140 water
July 20	P–40, E–70, T–70 water	T–70	.....	Control
July 29	.....	C–140	.....	.....
Aug. 6	.....	O–140	.....	.....
Aug. 13	.....	S–70	.....	.....
Aug. 20	.....	Control	.....	.....
Aug. 27	.....	P–35	.....	.....
Sept. 3	.....	E–70	.....	.....
Sept. 9	.....	T–70	Control	.....
Sept. 10	P–80, E–140, T–140 water	...	.....	.....
Sept. 13	P–40, E–70, T–70, C–100, O–100 grain	C–140	.....	.....
Sept. 15	Experiment terminated		.....	.....

[a] Treatments were administered in grain except where water administration is indicated; P=procaine penicillin (grain) and potassium penicillin (water), E=erythromycin, T=tylosin base (grain) and tylosin tartrate (water), C=chloramphenicol, O=oxytetracycline, S=streptomycin. Levels indicated are in mg. per animal per day.

[b] The antibiotics used in these studies were kindly supplied by the following: Burroughs, Wellcome and Co.—polymyxin B sulfate; Eli Lilly and Co.—erythromycin thiocyanate, tylosin base and tylosin tartrate; Merck Sharp and Dohme—procaine penicillin; Parke, Davis and Co.—Chloromycetin powder; Chas. Pfizer and Co.—oxytetracycline, potassium penicillin, and streptomycin sulfate.

[c] Miscellaneous treatments administered during the period June 17–26 consisted of various esters via grain and injections of carbacol, results of which are not discussed in this paper.

(Johnson *et al.*, 1960) that an ADM score of greater than 0.4 usually indicates that some serious bloat (score 3 or higher) has occurred. Each animal was weighed at the beginning of the season, on July 19 and at the end of the season.

During the period that Group IV received the P, E, T, C rotation in the drinking water, samples of the water were assayed for antibiotic activity. The period of storage, at 4° C., before assay never exceeded 24 hours. P, C and E levels were determined by methods summarized by Kirshbaum and Arret (1959), except that 12.7 cm. paper discs were used instead of cylinders. The assay method used for T was identical to that used for E.

Results and Discussion

The results of rotational feeding of antibiotics in grain are presented in figure 1 and table 2. The rotation, consisting of P-35, E-70, T-70, C-140, O-140 and S-70 (the numbers indicating milligrams per animal per day), prevented serious bloat during the first 6-week period. Bloat scores in the control group were low during the first administration of P and of E, thus making evaluation difficult. There was, however, much less bloat in the treated group; this observation, the data of Johnson *et al.* (1960), and other results presented in this paper affirm the efficacy of these treatments. Although streptomycin appeared to reduce bloat, one animal (score 3) was treated and several cases of mild bloat occurred during the first streptomycin-feeding period. Also, serious bloat in the control group occurred on only 1 day of that week. When the cycle was repeated, control was not so complete as desired during penicillin administration and was definitely inadequate during erythromycin

administration, indicating that "resistance" had not completely disappeared after a 5-week period of non-exposure to each antiboitic. After this period of erythromycin feeding there followed a long period of very low bloat in all groups, probably due to dry weather and a lack of good pasture. During this time, sequential feeding of antibiotics was continued

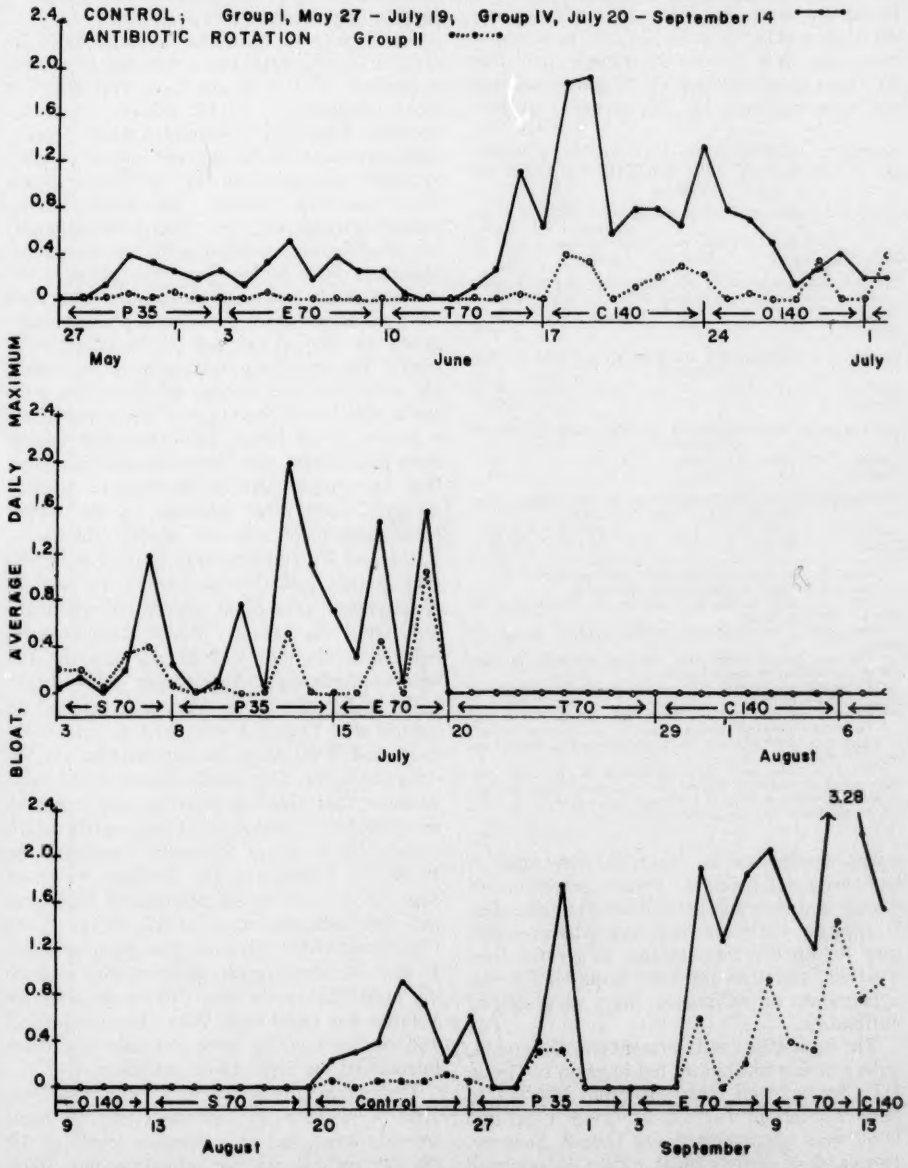

Figure 1. Effects of feeding antibiotics in rotation upon the average daily maximum bloat severity. (P=penicillin, E=erythromycin, T=tylosin, C=chloramphenicol, O=oxytetracycline, S=streptomycin). Numbers following the letters indicate mg. per animal per day.

as in the first rotation period; however, subsequent to streptomycin no antibiotic was fed for 1 week, thus extending to 6 weeks the period of non-exposure to each antibiotic. Essentially no bloat occurred in Group II during the week in which no antibiotic was fed, thus making it more difficult to interpret succeeding data. In the third cycle, penicillin may have been effective (if bloating potential had been regained by this group), erythromycin seemed to be more effective than it had been following a 5-week interim, but tylosin and chloramphenicol were not effective. It appears, therefore, that the interim necessary for an effective rotation is greater than 6 weeks, and that the time required for disappearance of resistance may vary among antibiotics.

TABLE 2. EFFECT OF ANTIBIOTIC TREATMENT ON BLOAT AND WEIGHT CHANGE OF CATTLE

Group	No. animals	Mean max. bloat [a]	No. cases of bloat of score 3 or above	Mean daily wt. gain, lb.
Rotation of antibiotics fed in the grain (May 27–July 7, 1960, inclusive).				
Control	16 [b]	.442	30	.74 [c]
Treated [d]	15	.091	1 [e]	1.34 [c]
Rotation of antibiotics fed in the grain (July 8–Sept. 9, 1960, inclusive).				
Control	15	.337	60	.82 [f]
Treated [d]	15	.079	7	1.15 [f]
Combination of antibiotics fed in the grain (May 27–Sept. 8, 1960, inclusive).				
Control	16 [g]	.362	81	.78
Treated [d]	15	.037	2 [h]	1.34
Combination of antibiotics administered in the drinking water (July 20–Sept. 9, 1960, inclusive).				
Control	15 [b]	.254	41	.82
Treated [d]	15	.041	4 [i]	1.45

[a] Mean of "average daily maximum bloat severities".
[b] One animal died of bloat during this period.
[c] The mean daily weight gain was for the period May 27–July 19, 1960, inclusive.
[d] See table 1 for antibiotic feeding schedule during this period.
[e] The one case of bloat that required treatment occurred during the feeding of streptomycin.
[f] The mean daily weight gain was for the period of July 20–Sept. 12, 1960, inclusive.
[g] Two animals died of bloat during this period.
[h] These two cases occurred on June 8; no bloat of score 3 or higher was observed after the antibiotic feeding levels were increased.
[i] Three of these cases occurred during the last two days when effect of treatment was waning. Likewise, these cases account for a major portion of the bloat represented by the .041 "mean maximum" in the treated group.

The most effective treatment was the combination of five antibiotics fed in grain to Group III (figure 2 and table 2). From May 27 to June 8 levels of P-20, E-35, T-35, C-50 and O-50 were administered. On June 8, however, two cases of serious bloat (score 3) occurred in that group; consequently the antibiotic levels were doubled (P-40, E-70, T-70, C-100 and O-100) on subsequent days. The latter levels resulted in excellent control until 3 days after the last day of administration on Sept. 8. Group III was exposed to the combination for 105 days without any indication of the development of antibiotic resistance.

The effects of antibiotics administered in rotation in the drinking water are presented in figure 3. P-35, E-70 and T-70 were effective bloat preventives; C-140, however, was ineffective. The level of administration of penicillin represents milligrams per animal per day of either procaine penicillin (grain) or potassium penicillin (water), the latter having greater activity per gram. Therefore, the number of units of penicillin added to the water was about 50% higher than that added to the grain. For all other antibiotics, the indicated levels in either grain or water represent milligrams per animal per day of the actual antibiotic. The antibiotic assays, made on drinking water samples during this rotation, indicated that erythromycin was quite stable for a period of 24 hours. Penicillin and tylosin were less stable, and there was an indication that the major part of the loss in activity occurred soon after addition to the water. Chloramphenicol was not readily soluble in water and its stability was quite low; these two factors probably accounted for its ineffectiveness as a bloat preventive when administered in water. Water temperatures reached a maximum of 31° C. and the pH was approximately 7.4 during these trials.

On July 20, Group IV was switched to control and Group I was used to test P-40, E-70 and T-70 given in combination via the drinking water. The results, figure 4 and table 2, show that this combination was effective until Sept. 9, a period of 51 days, after which serious bloat began to occur. Doubling the P, E and T levels in the drinking water on Sept. 10, 11 and 12 did not control bloat, nor did the combination of P-40, E-70, T-70, C-100 and O-100 given in the grain on Sept. 13 and 14. These results indicate that increasing antibiotic levels does little good once resistance has developed. Why chloramphenicol and oxytetracycline were not effective when introduced on Sept. 13 is not clear.

Polymyxin administration to Group IV from June 4 to June 11 had no effect on bloat severity when fed at successive levels of 35, 70, 140 and 280 mg. per animal per day. Polymyxin, a very active antibiotic against Gram negative bacteria, was tested because Garner

(1958) had reported that its use in treatment of sheep resulted in noticeable frothing of rumen fluid. From the standpoint of bloat etiology, it would be of interest to discover antibiotics which might increase the degree of bloat. Moreover, the most effective antibiotics

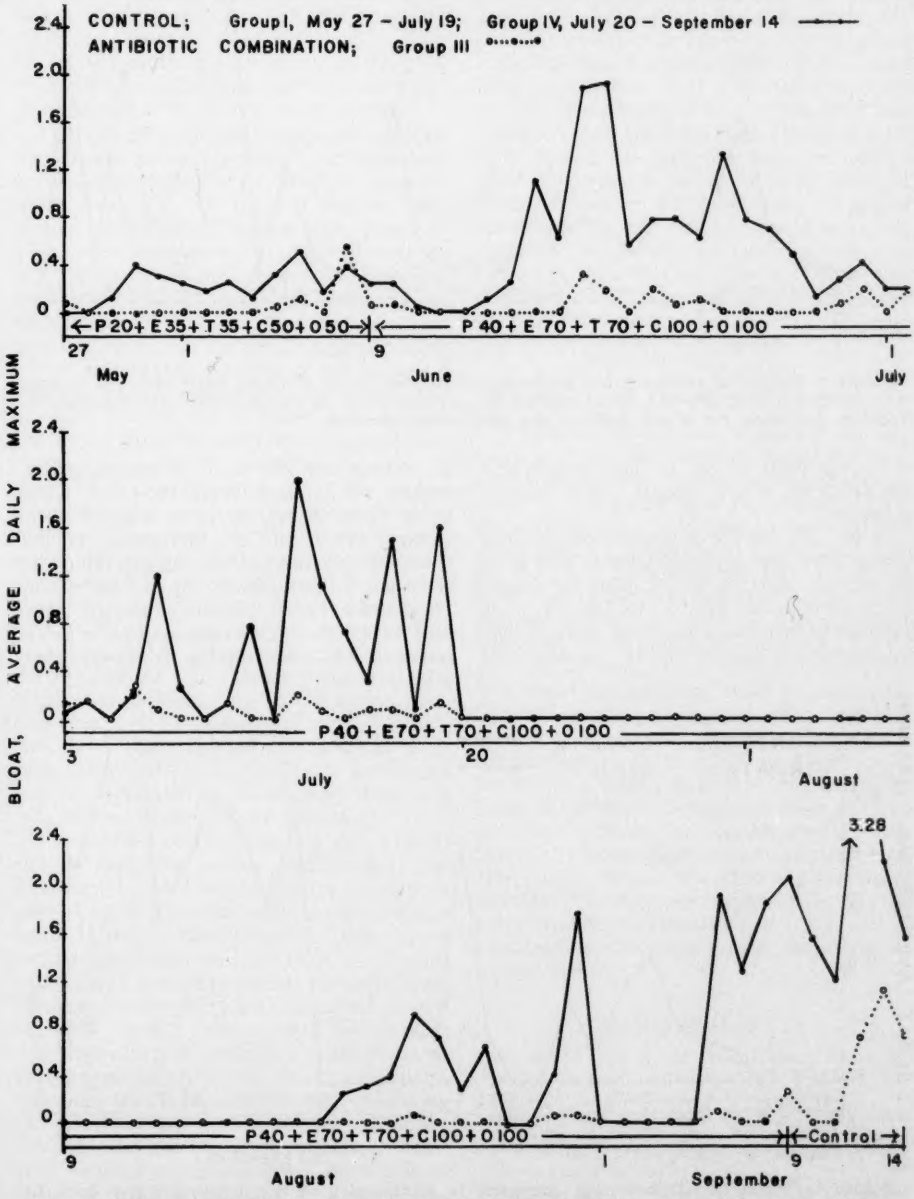

Figure 2. Effects of feeding antibiotics in combination upon the average daily maximum bloat severity. (P=penicillin, E=erythromycin, T=tylosin, C=chloramphenicol, O=oxytetracycline). Numbers following the letters indicate mg. per animal per day.

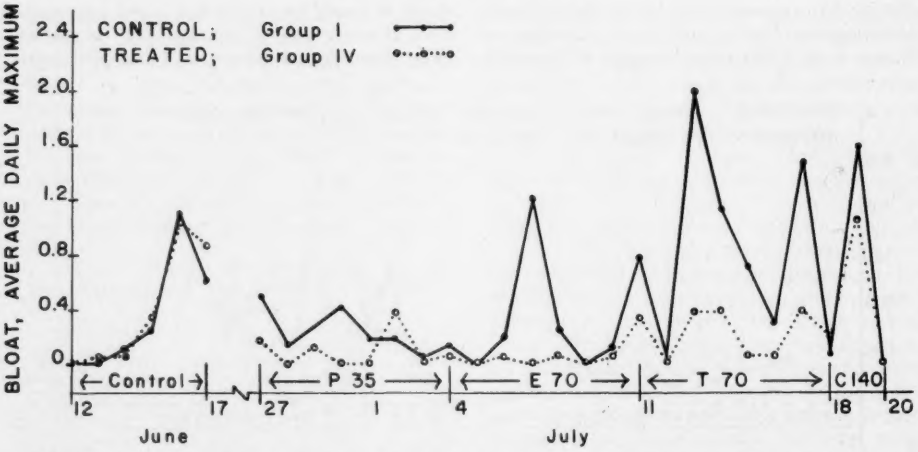

Figure 3. Effects of administering antibiotics in rotation in the drinking water upon the average daily maximum bloat severity. (P=penicillin, E=erythromycin, T=tylosin, C=chloramphenicol). Numbers following the letters indicate mg. per animal per day.

so far examined for use in bloat prophylaxis are primarily active against Gram positive organisms.

In no case did the administration of antibiotics have any apparent adverse effects on the animals. Average weight gains per animal in the period from May 27 to July 19, when a change in treatments was made, were: Group I (control), 39 lb.; Group II (rotation), 71 lb.; Group III (P, E, T, C and O combination), 79 lb.; and Group IV, 67 lb. Gains in the period from July 19 to Sept. 12 were: Group I (P, E, and T combination), 80 lb.; Group II (rotation), 63 lb.; Group III (P, E, T, C and O combination), 66 lb.; and Group IV (control), 45 lb. The four animals which died during the season were omitted in calculation of the average gains. It appears that,

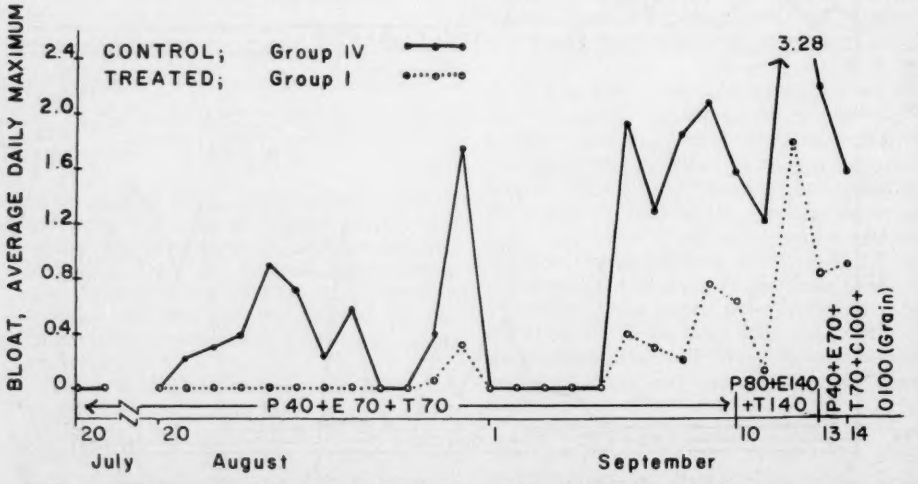

Figure 4. Effects of administering antibiotics in combination in the drinking water upon the average daily maximum bloat severity. (P=penicillin, E=erythromycin, T=tylosin, C=chloramphenicol, O=oxytetracycline). Numbers following the letters indicate mg. per animal per day.

under the conditions of this experiment, weight gains were substantially improved by antibiotic feeding because animals in these groups bloated less and, as a result, consumed more forage. Under conditions of less bloat the difference probably would be less. The effect on between-group differences in weight gains of limiting grazing time to 6 hours daily, as employed in this study, is not known.

The results presented herein demonstrate that bloat can be prevented over prolonged periods with appropriate methods of administering antibiotics. Of the two regimes used, feeding antibiotics in combination seems to offer more promise as a practical prophylactic measure because, in general, combinations control bloat more completely and for longer periods than do presently developed rotations. Also, the system of administration is less complicated. The use of a rotation of antibiotics would require a change at intervals of about 1 week, but it would have the advantage of requiring much less total antibiotic.

Although antibiotic levels in the final P, E, T, C, O combination used in this experiment probably were near the optimum, since the lower levels used early in the season were inadequate, further work with this and other combinations is needed to establish the most appropriate antibiotics and levels. The results with P, E and T in drinking water suggest that the C and O are important in prolonging the effect of the combination. Since there was substantial antibiotic loss in the water, however, the P, E, T combination might be effective for a longer period if administered in grain. Before the practicability of antibiotics in bloat prevention can be assessed, tissue and milk residue studies will be necessary.

The field use of a combination such as P, E and T would be greatly facilitated if the combination would be effective for as many or more days of treatment when given intermittently in two or more periods as when given in one continuous period. Then the combination could be used in periods of more serious bloat and removed when treatment is not necessary. Such a system might be indicated if ineffectiveness of antibiotics is the result of development of resistant strains of microorganisms which diminish in numbers during periods when the antibiotics are withheld. However, the true nature of antibiotic "resistance" in bloat remains unsolved. English *et al.* (1960) found that resistance to penicillin was manifest in several forms—the presence of penicillinase in some groups of bacteria, penicillin acylase activity in other groups and an unknown mechanism in selected groups of bacteria. In studies with single antibiotics, Hartman *et al.* (1960) observed increases in strains of rumen bacteria resistant to penicillin and erythromycin during periods of administration of these antibiotics, but this may have been unrelated to bloat since these resistant strains often developed long before bloat prevention ceased. Wiseman *et al.* (1960) suggest that instead of penicillin resistant strains developing when penicillin is administered, a change occurs in the proportions of rumen bacteria with a resultant increase in organisms capable of inactivating the penicillin molecule. Cole and Boda (1960) discuss, briefly, the development of resistance to antibiotics and the possible mode of action of antibiotics when used for prevention of bloat.

Summary

A rotation of antibiotics was fed sequentially in grain, each antibiotic being fed for a 1-week period. The rotation, consisting of penicillin (P), erythromycin (E), tylosin (T), chloramphenicol (C), oxytetracycline (O) and streptomycin (S), prevented serious bloat during the initial 6-week period. Two subsequent repetitions of the cycle indicated that penicillin regained effectiveness in the least time (about 6 weeks). The most effective treatment over a prolonged period was a combination of P, E, T, C and O fed in grain, which provided protection over the entire period (May to Sept.) in which it was fed. A water-administered combination of P, E and T prevented bloat for about 7 weeks. A weekly rotation of P, E and T seemed to be effective when given in the drinking water, but the water-administration of C which followed was ineffective, probably due to its poor solubility and low water stability. The average weight gains of the groups receiving antibiotics in rotation and in combination were much greater than those of control animals.

Literature Cited

Cole, H. H. and J. M. Boda. 1960. Continued progress toward controlling bloat. J. Dairy Sci. 43:1585.

English, A. R., T. J. McBride and H. T. Huang. 1960. Microbial resistance to penicillin as related to penicillinase or penicillin acylase activity. Proc. Soc. Exptl. Biol. Med. 104:547.

Garner, G. B. 1958. Effect of nitrate in the ration and a study of digestibility with sheep inoculated with *Pseudomonas aeruginosa*. Report of Conference on Rumen Function, Feb. 17, 1958, p. 22.

Hartman, P. A., R. H. Johnson, L. R. Brown, N. L. Jacobson and R. S. Allen. 1960. Effects of diet and feed additives on facultative anaerobes in the rumen. Report of Conference on Rumen Function, Feb. 18, 1960, p. 20.

Johnson, R. H., L. R. Brown, R. S. Allen, N. L. Jacobson and P. G. Homeyer. 1958a. Further observations on bloat etiology, prophylaxis and therapy. J. Animal Sci. 17:1219. (Abstr. and mimeo. suppl.).

Johnson, R. H., L. R. Brown, N. L. Jacobson and P. G. Homeyer. 1958b. Effectiveness and practicability of some oils, penicillin, decyl alcohol and lecithin in the control of alfalfa bloat. J. Animal Sci. 17:893.

Johnson, R. H., P. A. Hartman, N. L. Jacobson, L. R. Brown and H. H. Van Horn, Jr. 1960. Sustained prevention of bloat by feeding antibiotics in rotation or in combination. J. Animal Sci. 19:735.

Kirshbaum, A. and B. Arret. 1959. Outline of details for assaying the commonly used antibiotics. Antibiotics and Chemotherapy 9:613.

Mangan, J. L., A. T. Johns and R. W. Bailey. 1959. Bloat in cattle. XIII. The effect of orally administered penicillin on the fermentation and foaming properties of rumen contents. New Zealand J. Agr. Res. 2:342.

Wiseman, R. F., D. R. Jacobson and W. M. Miller. 1960. Persistence of lactobacilli and streptococci in the bovine rumen during penicillin administration. Appl. Microbiol. 8:76.

DEVELOPMENT AND APPLICATION OF ULTRASONIC METHODS FOR MEASURING FAT THICKNESS AND RIB-EYE AREA IN CATTLE AND HOGS [1]

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TEMPLE *et al.* (1956) indicated that ultrasonic fat measurements were readily obtained in live cattle. Other workers (Lauprecht *et al.*, 1957; Kliesch *et al.*, 1957; Panier, 1957) concluded that ultrasonic measurements of fat thickness in pigs were sufficiently accurate for practical application. Recently, Hazel and Kline (1959) found significant relationships between ultrasonic, ruler probe and carcass fat measurements as well as between ultrasonic measurements and percent lean cuts. Preliminary observations (Stouffer, 1959) indicated that the ultrasonic method held promise for measuring lean as well as fat. More recent attempts to measure rib-eye depth and area in hogs by other workers have been successful. (Price *et al.*, 1960a, b).

The foremost objective of this research was to develop an ultrasonic method of detecting the borders of the rib-eye and associated fat in live animals and simultaneously to record the results in a cross sectional photograph. This would permit rapid evaluation and measurement of rib-eye area and fat thickness in the live animal. A second objective was to test the accuracy and practical use of the method in the field with cattle and hogs.

Materials and Methods

Experimental Animals. The 327 cattle and 42 hogs used in this study were probed in nine separate groups from May, 1959, to June, 1960. Since the method and data were different for various groups the results were analysed separately. Preliminary results for Groups I-IV were reported by Stouffer and Wellington (1960). During probing, cattle were restrained in a chute or tied with halters and hogs were restrained in the corner of a pen.

Group I. Fifty-four Hereford steers at the Ohio Agricultural Experiment Station were evaluated by a Reflectoscope with a 1.0 mc. transducer. Nine individual depth readings were made at 1 or ½ in. intervals from the backline down over the rib on each animal. The readings were indivdually recorded with a 35 mm. camera for later interpretation. Carcass rib-eye area and fat thickness were determined from carcass tracings for comparison with similar ultrasonic measurements.

Group II. Eighty-two Hereford steers at the Ohio Agricultural Experiment Station were measured by a Reflectoscope and a 1.0 mc. transducer. Twelve to 15 depth readings were made on each animal at ½ in. intervals from the backline down over the rib to the lateral edge of the rib-eye muscle as determined by physical palpation. The cattle were slaughtered commercially and rib-eye and fat thickness values determined from ribbed carcass tracings.

Group III. Sixteen steers in a carcass contest at Texas A. & M. were measured with a Reflectoscope and a 1.0 mc. transducer. Fifteen to twenty depth readings were made on each animal at ½ in. intervals from the backline down over the rib.

Group IV. Forty-two hogs were evaluated at the Ohio State Swine Testing Station just prior to slaughter in Meat Laboratory using a Reflectoscope with a 1.0 mc. transducer. Readings were made at nine sites approximately over the 12th rib at 1 or ½ in. intervals off the midline at various angles of incidence. A scalpel was used to make small cuts in the skin at each site so that the carcass could be broken at the same place for comparison with carcass measurements. Ultra-

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sonic readings were repeated on 12 of the hogs in this group to measure the repeatability of this technique.

Group V. Forty-seven head of Hereford steers were evaluated at the Kansas State Experiment Station, Hays, Kansas using a Reflectoscope with a 1.0 mc. transducer. A coordinated scanning procedure was followed utilizing a Polaroid camera back on a Beattie Oscillotron for recording a complete cross section. The transducer was moved along the last rib from midline to a point 9 in. down on the side while the camera back was manually cranked along at a similar rate. The scope image was masked so that only the base line with void areas at the base of the pips was recorded during a scan. This procedure provided an opportunity to evaluate the complete record before the animal was released from the chute. Ultrasonic observations were repeated on 15 of the cattle in this group to measure the repeatability of this method. Rib-eye and fat thickness values were determined from ribbed carcasses for comparison with the ultrasonic observations.

Group VI. The electronically synchronized scanning technique was used on 15 slaughter cattle at Cornell University. A Reflectoscope with a 1.0 mc. transducer was used in this trial. Rib-eye and fat thickness values were obtained in the Meat Laboratory from ribbed carcass tracings for comparison with ultrasonic evaluations.

Group VII. Sixty-four slaughter cattle were measured ultrasonically at the Ohio State Experiment Station utilizing the same equipment and recording technique that was used in Group VI. However fat thickness values were not obtained from the commercial plant where the cattle were slaughtered. Only rib-eye area comparisons were made between ultrasonic and carcass measurements.

Group VIII. A Branson Sonoray with a 1.6 mc. transducer was used to evaluate 39 Hereford heifers at the Ohio State Experiment Station. The higher frequency transducer provided greater resolution of reflection images on the scope. The peaks of the pips on the scope were saturated at a constant level and this area was masked and used for recording purposes rather than the baseline which was used in earlier trials. Fat thickness measurements were not obtained from the packing plant in this trial.

Group IX. Ten breeding cattle in the Cornell University herd were probed by one operator on each of 2 days using the same equipment that was used for Group VIII to evaluate the repeatability of the method. The resulting pictures (one for each animal on each day) were evaluated separately by two technicians and measurements obtained. These cattle were not slaughtered.

Equipment and Technique. A Sperry Reflectoscope with a 1.0 mc. transducer was used in Groups I–VII and a Branson Sonoray with a 1.6 mc. transducer was used in Groups VIII and IX. The ½-in. diameter, type Z transducers were manufactured by Branson Instruments, Inc. Reflected signal images resulting from individual soundings were recorded with a 35-mm. camera on the oscilloscope and later interpreted for depth measurements in Groups I–IV. These values were plotted and a picture similar to a cross-sectional tracing of a rib resulted using the method described by Stouffer (1959) for cattle and hogs and later used by Price *et al.* (1960a) with hogs. The area of estimated rib-eye muscle and external fat thickness were measured from the plotted outline. This method was very time-consuming.

A Beattie Oscillotron recording device with a Polaroid Land Back (figure 1) was used in Groups V–IX in order to obtain complete cross sectional pictures in a short time. The camera back was mounted on a movable slide which provided the opportunity of recording numerous readings as a continuous scan on a single picture. In evaluating Group V, this procedure was utilized to produce a complete simulated cross section (figure 4) by coordinating the movement of the transducer on the animal's back with the movement of the camera back manually. Partially masking the scope image permitted exposure of limited areas of the film during the scanning processes. The 10-second film developing process was of value in this application because immediate development and evaluation of the picture insured a complete display while the animal was still restrained.

The procedure was further automated for use in Groups VI through IX by mounting a small gear train, motor and control potentiometer on the recording camera (figure 1). A second potentiometer attached to a rubber belt that was placed on the animal's back was driven by the movement of transducer across the animal's back (figure 3). These movements were elctro-mechanically synchronized by means of the potentiometers, motor and gear train thus described and companion amplifier (figure 2).

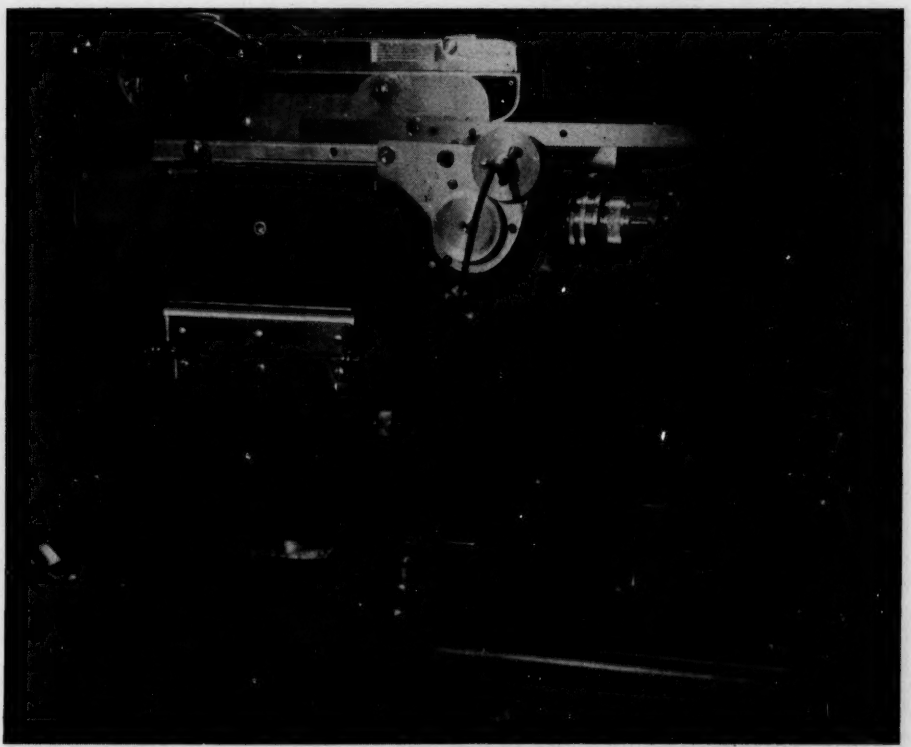

Figure 1. Reflectoscope equipped with a Polaroid camera back used in ultrasonic scanning technique. The motor and associated gear train (a) and the horizontal control drive (b) permit synchronized camera and transducer movements and a recorded profile curvature of the area probed on the animal.

In order to record the profile curvature over the contour of the last rib on the pictures a curve was built into a cam pulley and mounted to the horizontal image control of the instrument. Mechanical coupling with the camera gear shaft (figure 1) by means of a flexible shaft, pulley and nylon thread permitted the curve to be built into the scope image automatically and consistently as the scan was made.

Regular 20- or 30-weight motor oil was used as a couplant between the transducer and the animal's hide to insure air free contact in all trials. Clipping the hair was not necessary but more oil and greater sensitivity settings were required when the animals were not clipped.

Calibration and Operation. Calibration of the signal on the instrument for use with cattle and hogs was determined by inserting steel needles into freshly slaughtered meat in the beam path at 1 in. intervals from the surface. Additional adjustments were necessary when the scanning procedure was used in Groups V–IX. The sweep length control was then adjusted to calibrate the scope to the movement of the camera. Thus, a scaled 1-in. movement of the camera was equal to a scaled 1-in. of penetration, shown on the oscilloscope. A marker was photographed onto the edge of the picture and used for reference in later evaluation. The equipment was checked for linear and depth calibration each time after moving, or setting up, and at various intervals during the probing.

The belt and potentiometer were positioned on the animal's back over the last rib and oil applied to the hide. The midline of the back on the live animal was used for a reference point and the scan was started about 1 in. beyond this line to permit reflections from the vertebral processes to appear as a point of

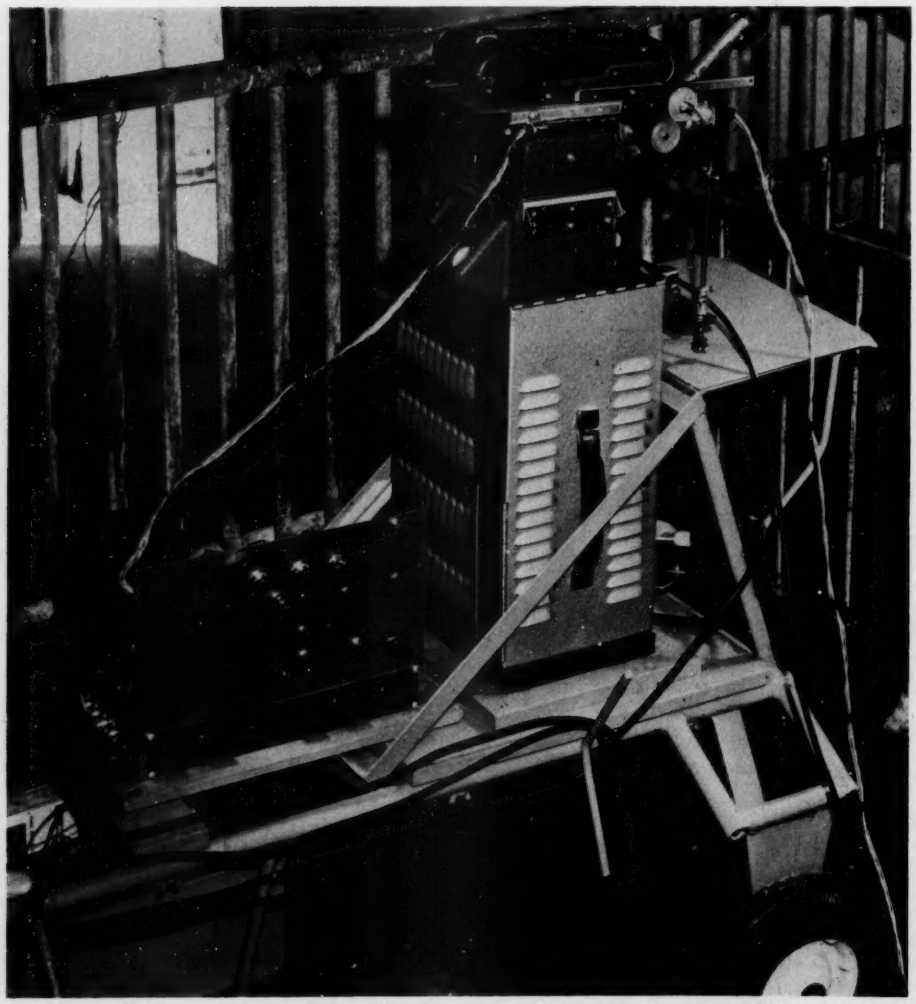

Figure 2. Ultrasonic instrument (Sonoray) with electro-mechanical scanning and recording equipment used in Groups VIII and IX.

reference on the picture. A preliminary scan crossing the vertebral processes and on down past the edge of the rib-eye was made to insure that the signal continuity was maintained. The transducer was then connected to the potentiometer and the actual scan made with the shutter held open while the camera moved from 0 to 9 in. An angle deflection device (figure 3) was clamped to the transducer to insure that a constant angle was maintained.

A marker was next photographed and the picture developed. The resulting cross sectional picture was then visually evaluated for completeness. Normally a second scan was made at a slightly different sensitivity setting. The average total time required for the entire process was approximately 3 to 5 minutes per animal when two recorded scans were made. Two operators were required for the procedure.

Evaluation of Photographs. The vertebral

processes were used as a point of reference in the live animal and on the picture. The amplitude of the reflected signal is largely dependent on the angle at which it strikes the connective tissue or area of differing density. Thus, the ventral boundaries of the rib-eye which are somewhat perpendicular to the beam path cause marked reflections whereas the lateral boundary of the rib-eye, for the most part, approached a vertical position which made this boundary somewhat less marked in the pictures. The reference point that is observed most consistently in this area is the *longissimum costarum* muscle positioned just ventral and lateral to the lateral border of the rib-eye (figure 4). It is obvious that evaluation of this ultrasonic display requires knowledge of the anatomy of the region being probed.

The direct measurement of the cross sectional display of the rib-eye was made by tracing the boundaries onto transparent overlay material and then measuring the overlay. Knowing the scale of the picture, a mathematical factor was used to convert to the actual area.

Results and Discussion

The application of the method described to cattle and hogs was practical with only minimum animal restraint. The earlier technique of plotting numerous photographic records of individual probes required an excessive amount of time. In Groups V through IX the use of the scanning technique produced a cross-sectional display of the fat and lean areas at the 13th rib of live cattle.

Means and standard errors for the ultrasonic and carcass rib-eye area and fat thickness measurements are shown in table 1. Simple correlation coefficients between the ultra-

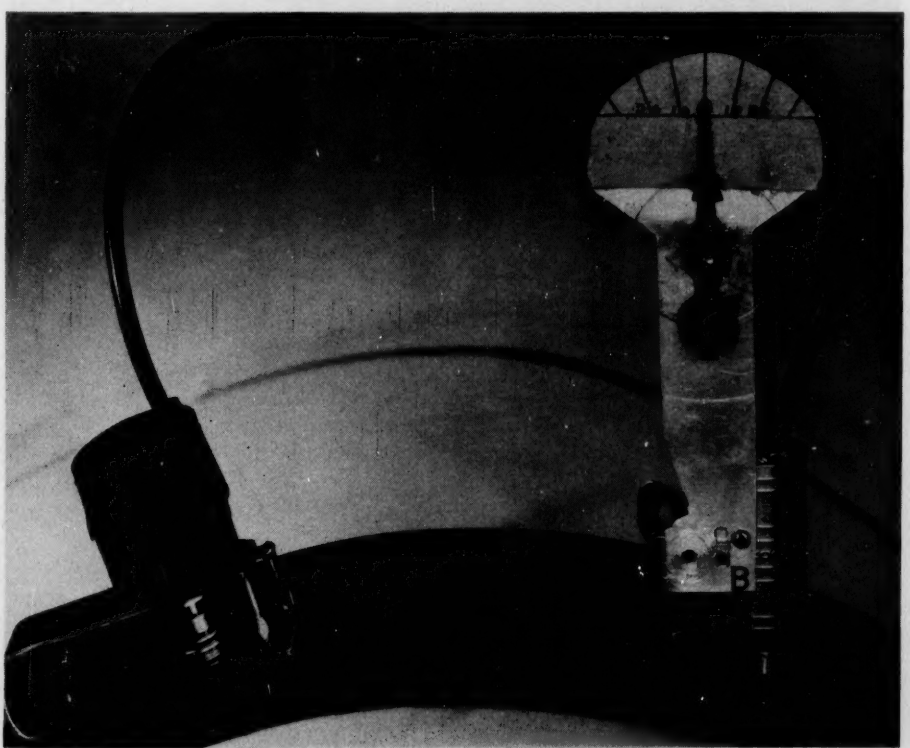

Figure 3. The rubber belt placed with the slot over the 13th rib serves as a mounting for the potentiometer and pulley assembly (a) while the transducer and angle deflection device (b) are manually moved over the hide.

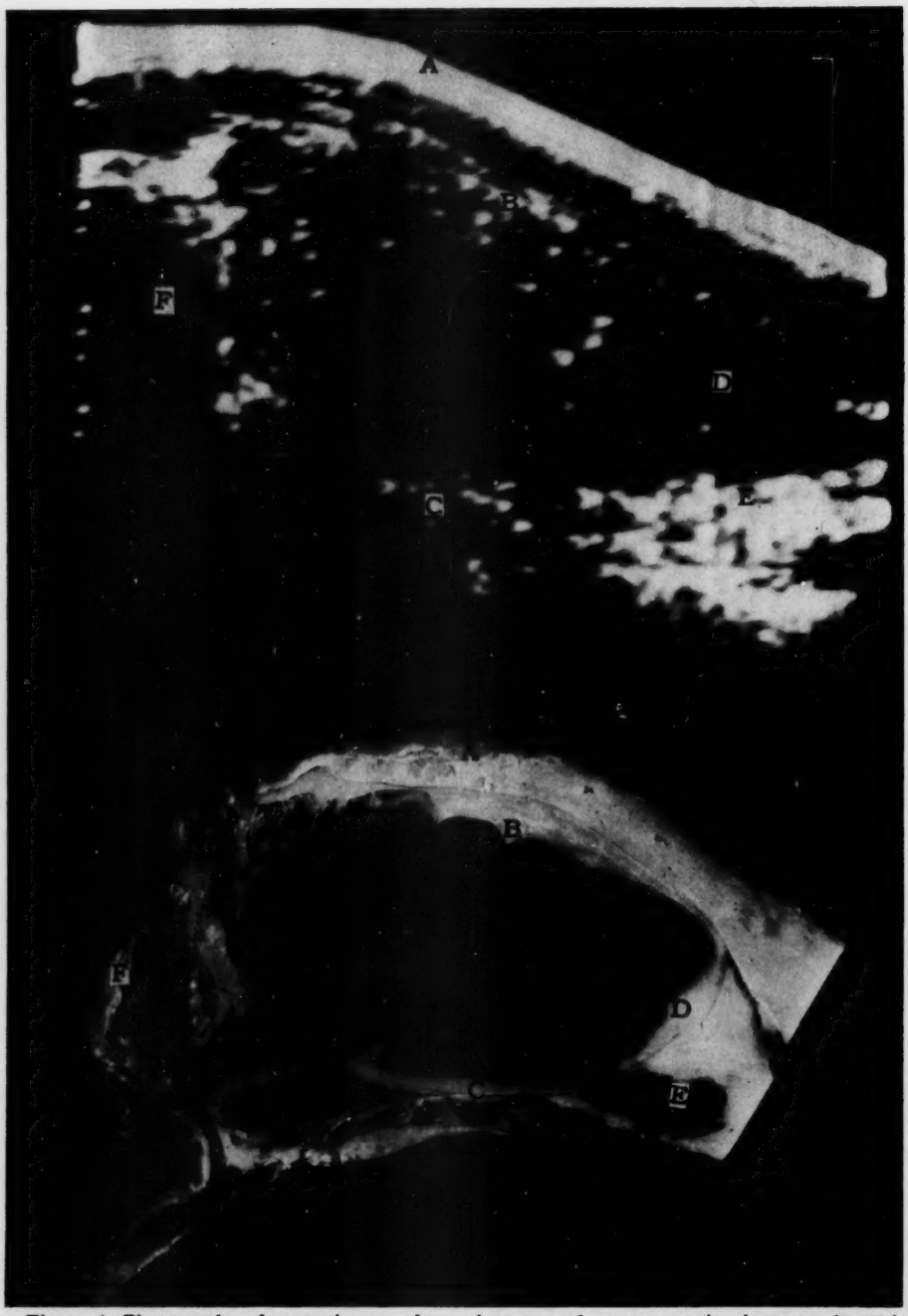

Figure 4. Photographs of a continuous ultrasonic scan and a cross sectional cut at the 13th rib of a steer. Signals are reflected from the hide (a) the dorsal (b) ventral (c) and lateral (d) borders of the rib-eye as well as from the longissimus costarum (e) and the vertebral process (f).

TABLE 1. MEANS AND STANDARD ERRORS FOR ULTRASONIC AND CARCASS MEASUREMENTS OF FAT THICKNESS OR RIB-EYE AREA

Group no.	No. animals	Method of measurement	Fat thickness	Rib-eye area
I	54	U [a]	0.55±0.01	11.40±0.24
		C	0.64±0.04	9.27±0.11
II	82	U	0.66±0.01	10.31±0.15
		C	0.74±0.02	11.69±0.12
III	16	U	0.73±0.02	9.46±0.34
		C	0.72±0.05	10.22±0.37
IV	42 [b]	U	1.20±0.04	4.12±0.09
		C	1.35±0.04	4.08±0.09
V	47	U	0.58±0.02	11.74±0.30
		C	0.90±0.03	12.02±0.18
VI	15	U	0.37±0.02	8.47±0.30
		C	0.47±0.07	11.48±0.18
VII	64	U	... ± ...	8.13±0.18
		C	... ± ...	8.91±0.15
VIII	39	U	... ± ...	9.33±0.22
		C	... ± ...	10.21±0.15

[a] U=ultrasonic. C=carcass.
[b] Hogs were used in this group. All other groups were cattle.

sonic and carcass measurements are given in table 2. The underestimation of fat depth may be partially due to the amount of pressure against the hide with the transducer and partially to differences in amount of fat thickness between the 12th and 13th ribs. The average rib-eye area measured ultrasonically was smaller than the carcass rib-eye area in most groups. The depth of rib-eye measured ultrasonically was significantly correlated with the carcass measurements for all groups in which it was obtained. This measurement was consistently easier to obtain ultrasonically than was rib-eye length as is indicated by the larger correlation coefficients. Slight changes in sonic velocity from fat to lean may account for some of the variation in ultrasonic and carcass rib-eye depth.

The lowered correlation coefficient between the ultrasonic and carcass rib-eye areas in Group II is believed to be due, in part, to an attempt to locate the extent of rib-eye width by physical palpation and subsequent use of this value in plotting the ultrasonic cross section. A repeated error in physically locating the lateral boundary of the rib-eye was apparently made. An explanation of the occurrence of similar values for rib-eye length in Groups III and VIII (table 2) is not possible. The higher correlation coefficients observed for Group III were probably obtained because 15 to 20 transducer positions at ½-in. intervals were used in the evaluations.

TABLE 2. CORRELATION COEFFICIENTS BETWEEN ULTRASONIC MEASUREMENTS OF FAT THICKNESS AND RIB-EYE AREA IN LIVE ANIMALS AND CARCASS MEASUREMENTS

Group no.	No. animals	Fat thickness	Rib-eye area	Rib-eye depth	Rib-eye length
I	54	0.35**	0.49**	0.30*	0.32*
II	82	0.32**	0.22*	0.21*	−.01
III	16	0.54**	0.85**	0.84**	−.01
IV	42 [a]	0.92**	0.70**	0.47**	0.68**
V	47	0.42**	0.57**	....	....
VI	15	0.04	0.58*	0.57*	0.35
VII	64	....	0.42**	....	....
VIII	39	....	0.42**	0.55**	−.09

* P<.05.
** P<.01.
[a] Hogs were used in this group. All other groups were cattle.

The ultrasonic fat measurements in hogs (Group IV) were more accurate than in cattle. This is probably due to the greater fat depth since the signal from the fat-lean interface is deeper in fatter animals and is not overlapped with initial signals occurring near the hide. When the 1.0 mc. frequency was used, more overlapping of initial signals occurred than with higher frequencies. These studies were aimed at producing the cross sectional area of lean with fat measurements considered as secondary. The occurrence of lower correlation coefficients for fat measurements in Group VI appears to be due to small numbers and several large individual differences between the ultrasonic and carcass measurements. Similarly the lower relationship of rib-eye areas measured ultrasonically and in the carcasses of cattle apppeared to be largely due to several under or over estimations of 2 or 3 sq. in. These errors were generally caused by misinterpretation of the lateral boundary of the rib-eye.

The validity of comparing carcass rib-eye area with ultrasonic rib-eye area is not certain. The effect of slaughtering, hanging, splitting and shrouding on the shape and size of the rib-eye as well as the fat is not clear. Lauprecht *et al.* (1957) found that fat measurements in live hogs were more closely related to carcass chilled in the standing position than to those in the hanging position. This discrepancy warrants more investigation.

Observations of the carcass tracings for Groups I, II, VII and VIII indicated that the position of quartering the carcass varied considerably between the 12th and 13th ribs. In a simultaneous study of variation in rib-eye area between ribs (Stouffer *et al.*, 1961) the carcasses in Group VI were broken at the 13th rib on the right side and for comparison the 12th–13th rib section from the left side was removed, frozen and sliced at five intervals. The ultrasonic area appeared to be related more to the area of the middle slices than to slices on or next to either rib. Differences in fat thickness were also noted. A slight difference in the position of the probing

TABLE 3. MEANS AND STANDARD ERRORS FOR REPEATED ULTRASONIC MEASUREMENTS OF FAT THICKNESS AND RIB-EYE AREA IN LIVE ANIMALS

Group	Observation	Fat thickness	Rib-eye area
		in.	sq. in.
IV (12 hogs)	1	1.16±0.06	3.56±0.14
	2	1.18±0.08	3.56±0.13
V (15 cattle)	1	0.45±0.04	10.81±0.66
	2	0.45±0.03	10.88±0.69
IX (10 cattle)			
Technician A	1	1.00±0.07	12.22±0.62
	2	0.98±0.07	11.36±0.62
Technician B	1	0.96±0.07	11.99±0.54
	2	0.89±0.06	11.02±0.41

scan and of the subsequent quartering of the carcass could possibly account for some of the lowered correlations. More research in this area is necessary.

Repeatability Studies. The means and standard errors obtained in the three repeatability studies are shown in table 3. Correlation coefficients between repeated ultrasonic measurements of rib-eye area and fat thickness are shown in table 4. Correlation coefficients for fat thickness and rib-eye area (0.95 and 0.84, $P<.01$) were obtained for the repeated measurements on the hogs in Group IV. The significant relationship of the repeated ultrasonic measurements of fat thickness and rib-eye area (0.67 and 0.89, $P<.01$) in Group V is noteworthy in that the camera back was moved manually across the oscilloscope.

In Group IX the rib-eye area values obtained by two different technicians from the same picture gave correlation coefficients of 0.67 ($P<.05$) for the first day and 0.81 ($P<.01$) for the second day. The pictures taken the second day were more sharply defined than those taken the first day which probably accounts for the increased correlation. Fat thicknesses were more highly correlated between technicians (0.81 and 0.87, $P<.01$) than rib-eye areas.

TABLE 4. CORRELATION COEFFICIENTS BETWEEN REPEATED ULTRASONIC MEASUREMENTS OF FAT THICKNESS AND RIB-EYE AREA IN LIVE ANIMALS

Group	Fat thickness	Rib-eye area
IV (12 hogs)	0.95**	0.84**
V (15 hogs)	0.67**	0.89**
IX (10 cattle)	....	....
Between observations		
Technician: A	0.90**	0.71*
B	0.75**	0.90**
Between technicians		
Observation: 1	0.81**	0.67**
2	0.87**	0.81**

* $P<.05$.
** $P<.01$.

The correlation between observations taken on the 2 days were significant in all cases but somewhat different between the first technician (0.71, $P<.05$) and the second technician (0.90, $P<.01$). The correlation betwen days for fat values was higher for the first technician (0.90, $P<.01$) than for the second technician (0.75, $P<.01$).

The number of observations involved in these studies gave coefficients significantly different from zero and indicate that significant repeatability of the method can be expected. The correlation of rib-eye area between technicians indicates that the interpretation of the photographs is a source of variation. Deviations between the two observations on the same animal were too great in several cases for practical application. No satisfactory explanation of the difference in rib-eye area is possible. Differences in location of probing site, probing pressure, changes in velocity and muscle tonus between probing periods are possible deviations requiring more study.

It can be concluded from the results of these studies that at present the instrumentation and techniques are not sufficiently accurate to be used as a commercial selection tool. However, the principle and sensitivity of the method warrant further refinement of the technique. Anatomical knowledge of the area to be examined ultrasonically is essential and the human element in the interpretation of the photographs is a major source of variation. More resolution of the reflected signals through development of instrumentation would greatly reduce the errors of interpretation.

Summary

An ultrasonic technique was developed and used to produce cross-sectional outlines of the rib-eye and associated fat at the 13th rib of cattle and hogs. The procedure varied with development of technique and instrumentation from individual recording and plotting of reflected signals from numerous probings to a mechanized scan with one resulting photographic display. Since the procedure and data varied for different groups the data were treated in eight groups containing a total of 327 cattle and one group of 42 hogs.

Correlation coefficients for ultrasonic and carcass fat thickness measurements were lower in most cases than those reported by other workers since the 1.0 mc. frequency was used to obtain greater penetration. Comparison of ultrasonic rib-eye areas with carcass rib-eye areas gave significant but low correlation coefficients. These relationships were higher for hogs than for cattle.

Comparison of repeated ultrasonic measurements indicated a significant repeatability of the method. Limited data suggest that the positional variation of rib-eye area and fat thickness between the 12th and 13th ribs, changes of shape and size of the rib-eye due to slaughtering, hanging and variability in pressure of the transducer against the hide during probing, are probable factors accounting for low relationships between ultrasonic and carcass measurements. The results of these investigations warrant additional refinement of the described technique in order to increase resolution and simplify evaluation of the results.

Literature Cited

Hazel, L. N. and E. A. Kline. 1959. Ultrasonic measurement of fatness in swine. J. Animal Sci. 18:815.

Kliesch, J., U. Neuhaus, E. Silber and H. Kostzewske. 1957. Versuche zur Messung der Speckdicke am lebenden Tier mit Hilfe des Ultraschalls. (Studies of measurement of fat thickness of live animals with the help of ultrasonics). Zeit. Tierz. Zuchtungsbiol. 70:29.

Lauprecht, E., J. Scheper and J. Schroder. 1957. Messungen der Speckdicke lebender Schweine nach dem Echolotverfahren. (Measuring the back fat thickness of live pigs with echo-ranging techniques). Mitt. dtsch. Landw. Ges. 72:881.

Panier, C. 1957. Les ultrasons dans la determination de l'etat d'engraissment des porcs. (Ultrasonics in the determination of the state of fatness of hogs). Revue de l'agriculture. 10:482.

Price, J. F., A. M. Pearson and J. A. Emerson. 1960a. Measurement of the cross-sectional area of the loin eye muscle in live swine by ultrasonic reflections. J. Animal Sci. 19:786.

Price, J. F., A. M. Pearson, H. B. Pfost and R. J. Deans. 1960b. Application of ultrasonic reflection techniques in evaluating fatness and leanness in pigs. J. Animal Sci. 19:381.

Stouffer, J. R. 1959. Status of the application of ultrasonics in meat animal evaluation. Proc. Twelfth Ann. Reciprocal Meat Conference. National Live Stock and Meat Board. 161.

Stouffer, J. R., A. Diekmann, M. V. Wallentine and G. H. Wellington. 1962. Variation in rib eye area and fat measurements between the 12th and 13th ribs of beef carcasses. J. Animal Sci. (In Press).

Stouffer, J. R. and G. H. Wellington. 1960. Ultrasonics for evaluation of live animal and carcass composition. Proc. Twelfth Research Conference, American Meat Institute Foundation, 81.

Temple, R. S., H. H. Stonaker, Douglas Howry, Gerald Posakony and M. H. Hazaleus. 1956. Ultrasonic and conductivity methods for estimating fat thickness in live cattle. Proc. West. Sect. Am. Soc. An. Prod. 7:477.

ARSANILIC ACID AS A THERAPEUTIC AND PROPHYLACTIC AGENT FOR HEMORRHAGIC DYSENTERY

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HEMORRHAGIC dysentery — long an enigma to the swine grower, veterinarian, and research worker—still exacts heavy financial losses. Doyle (1959) gives a complete description of the disease complex. It is essentially a catarrhal enteritis involving the cecum and the colon, characterized by the passage of mucus and blood. The stomach may be hyperemic. Generally there is little or no febrile response. In contrast, pigs suffering from a *Salmonella choleraesuis* infection have little blood in the stools. In the latter the entire intestinal tract is often involved, including the small intestine, and there is usually a marked febrile response.

Sodium arsanilate added to the drinking water has been shown to be an effective therapeutic agent for hemorrhagic dysentery (Boley *et al.*, 1951; Langham *et al.*, 1952; Rosoff and Abel, 1953). Preliminary reports (Patrias 1952, 1953) have indicated a similar value for arsanilic acid when it is included in the feed. The positive effects of various arsonic acids in an experimental herd was ascribed by Carpenter (1951) and by Carpenter and Larson (1952) partly to control hemorrhagic dysentery.

Lubbehusen (1956) has succinctly stated the case for a medicated feed service program. The addition of arsanilic acid to the feed provides a sure, and possibly more convenient, way of regulating the dosage rate as compared with the addition of sodium arsanilate to the drinking water. This is important when one considers the relatively narrow tolerance range of swine for arsanilic acid (Frost and Spruth, 1956). Furthermore, appetite is not as severely affected in pigs suffering from hemorrhagic dysentery as it is in some enteritic conditions. Thus, water medication is not obligatory.

The purpose of this investigation was to test the effects of adding graded levels of arsanilic acid to the feed of swine suffering with hemorrhagic dysentery.

Experimental

The basal diets used in all the experiments are given in table 1. Diet 1 contained 16% protein and was fed from the start of the experiments until the pigs weighed 100 to 125 lb., when Diet 2 containing 12% protein was used. The required amount of arsanilic acid (AA) was added as a 20% premix in soybean oil meal.[3] Sodium arsanilate (NaA) was provided in the form of tablets which contained 668 mg. of NaA, the sodium salt of AA. The addition of one tablet per gallon of water provided 175 ppm NaA, which is equivalent to 160 ppm AA. The tablets were dissolved in a small amount of warm water to insure their complete dissolution before adding them to the main water supply. The NaA was alternately provided for 5 days and then withdrawn for 2 days for the duration of the experiment.

The animals prior to the initiation of the test had been vaccinated for cholera and erysipelas. Animals which died were necropsied with special attention being given to signs of gastroenteritis. Also smears and/or cultures were taken from the intestinal tract to determine the presence or absence of *Vibrio coli*. The data were analyzed by analysis of variance.

Experiment 1. Following an outbreak of hemorrhagic dysentery, 80 pigs weighing approximately 140 lb. were formed into outcome groups on the bases of their average daily gain during the preceding week, incidence of scouring and body weight. Animals were then allotted at random from these outcome groups to the following treatments: Basal (B), B plus 100 ppm AA, B plus 200 ppm AA, B plus 250 ppm AA, and B plus 175 ppm NaA in the drinking water. These treatments were replicated once. The pigs were weighed weekly and observed individually until they defecated to

[1] The authors are grateful to K. M. Prinz for his aid in the necropsy of animals in one of the experiments.

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[3] Pro-Gen, 20%, Abbott Laboratories, North Chicago, Illinois.

determine if they were or were not scouring. Feed consumption also was recorded. The experiment lasted 4 weeks.

Experiment II. This study, like the previous one, was designed following an outbreak of hemorrhagic dysentery to study the therapeutic value of various dietary levels of arsanilic acid. In this experiment 97 pigs weighing approximately 75 lb. were placed on test using the same allotment procedure and treatments as those described for Experiment I, with the following exception. The animals which received the B plus 200 ppm AA and B plus 250 ppm AA received these diets for 4 weeks and then the basal diet alone for one week. This alternating procedure, 4 weeks' treatment and 1 week off the drug, was followed for the duration of the test, which lasted 11 weeks.

TABLE 1. COMPOSITION OF BASAL DIETS [a]

Ingredient	Percent in diet no. 1	Percent in diet no. 2
Ground yellow corn	77.50	89.50
Soybean oil meal	10.753	4.779
Meat and bone scraps	9.00	4.00
Dehydrated alfalfa meal	2.25	1.00
Limestone	....	.50
Salt	.45	.20
Vitamin and trace mineral mixture [b]	.047	.021
	100.000	100.000

[a] Diet No. 1 fed until the pigs weighed between 100–125 lb. and then Diet No. 2 was used.

[b] Composition in grams per kg. choline chloride, 26.7; calcium-DL-pantothenate, 26.4; vitamin B_{12}, .027; nicotinic acid, 24.5; riboflavin, 5.3; viosterol (1 x 10^6 I.U./gm.), 64; trace minerals (Calcium Carbonate Company, No. 244), 606; zinc oxide, 197; inert ingredients, 113.4.

Experiment III. To compare the effects of graded levels of arsanilic acid in the diet as prophylactic agents for hemorrhagic dysentery, 100 weanling pigs weighing between 40 to 50 lb. were used. The pigs were formed into outcome groups with reference to body weight, sex and breeding and then allotted at random from these groups to the experimental treatments. The treatments were as follows: Basal (B); B plus 100 ppm AA; B plus 200 ppm AA; B plus 250 ppm AA. Twenty pigs were assigned to each treatment with the exception of the basal which had 40 pigs divided between two lots containing 20 pigs each. This experiment was conducted on pasture in contrast to Experiments I and II, which were conducted on drylot.

Half of the pigs from each treatment (i.e. 10 pigs) were orally challenged with a milk suspension of homogenized gastrointestinal tracts from pigs suffering with hemorrhagic dysentery, and from which viable *Vibrio coli* was isolated. The remaining half were exposed to the infection by housing them with the orally challenged animals. The milk suspension was prepared by homogenizing the entire gastrointestinal tracts and their contents from three pigs using a Waring Blendor. The homogenate was added to 15 gal. of milk, which was divided equally among the groups.

Pigs were weighed weekly, feed consumption determined and the pens checked for the presence of bloody scours.

Results and Discussion

Experiment I. Table 2 contains a summary of the data for this experiment. Though all groups showed some improvement in average daily gain, the groups receiving AA had the highest values, followed by the group receiving NaA. Statistical analysis of the growth data showed the difference between the controls and groups receiving AA to be close to the 5% level of significance. There was essentially no difference in the gains made among the 3 different levels of AA. The data for feed efficiency also show an improvement for the treated groups with the group receiving 250 ppm AA showing most improvement. It is perhaps worthy of note here that no pigs which received AA or NaA were scouring at the end of the experiment, whereas two pigs were scouring in the control lot.

A comparison of the average daily gains for the control lot at the start and end of the experiment suggests these animals recovered spontaneously from the disease. This agrees with the general concept that hemorrhagic dysentery is to a degree self-eliminating and cyclic in character. In further support of this contention is the fact that 24 pigs out of 120 in the group died from hemorrhagic dysentery prior to the start of this test. Only one pig died during the experiment.

Experiment II. This experiment was similar to Experiment I, with the exception that the treatment duration of the two highest levels of AA was varied. Results are given in table 3.

In this experiment the additions of AA at 200 or 250 ppm of the diet or 175 ppm of NaA in the water resulted in a significant increase in average daily gain ($P<0.01$). While the

TABLE 2. EFFECTS OF ARSANILIC ACID OR ITS SODIUM SALT AS THERAPEUTIC AGENTS FOR HEMORRHAGIC DYSENTERY, EXPERIMENT I

Lot no.	3 and 12	1 and 9	6 and 8	5 and 7	4 and 11
Treatment[a]	Basal	Basal+100 ppm of AA	Basal+200 ppm of AA	Basal+250 ppm of AA	Basal+175 ppm NaA in the water[b]
No. of pigs	16	16	16	16	16
Av. body wt., lb.					
Start	139.1	142.7	157.8	137.0	141.0
End	180.0	194.6	209.0	189.8	187.7
Av. daily gain, lb.					
Preexperimental[c]	1.06	0.66	0.75	0.53	0.56
Experimental period	1.40	1.76	1.78	1.80	1.61
Av. daily feed intake, lb.	5.54	5.92	5.92	5.44	5.33
Feed/lb. gain, lb.	3.94	3.36	3.34	3.01	3.30
Number scouring					
Start	4	4	4	4	4
End	2	0	0	0	0
Mortality	0	1	0	0	0

[a] Duration of the experiment was 4 weeks.
[b] Alternately provided for 5 days and withdrawn for 2 days during the duration of the experiment. 175 ppm of NaA equivalent to 160 ppm of AA.
[c] Average daily gain for a 1-week period prior to the start of the experiment.

effect of AA at 100 ppm was not as marked in this test as in Experiment I, there was still some response in average daily gain. There appeared to be above normal feed wastage during this test; thus the data for feed efficiency may be in error.

The mortality rate in Experiment II is markedly greater than that for Experiment I. In Experiment I the animals were not started on therapy until several weeks after the initial symptoms of hemorrhagic dysentery were observed. In Experiment II they were started on test two days after the initial symptoms were observed. There were no death losses in the groups of pigs which received 250 ppm AA in the feed or 175 ppm NaA in the water; whereas there was a 30% mortality rate in the basal group, 25% in the group receiving 100 ppm AA, and 20% in the group receiving 200 ppm AA.

Pigs were not checked individually for scours in this test, but rather the pens were checked each weigh day. The most profuse scouring occurred during the first 4 weeks of the experiment. The lots receiving either 175 ppm NaA in the water or 250 ppm AA in the feed showed the earliest remissions. However, during the remaining 7 weeks evidence of bloody scours was seen sporadically among all the treatment groups as well as the controls.

Experiment III. The results of this test are presented in table 4. The method of infection, i.e. either by oral challenge or contact,

TABLE 3. EFFECT OF ARSANILIC ACID GIVEN FOR VARIOUS TIME PERIODS OR ITS SODIUM SALT AS THERAPEUTIC AGENTS FOR HEMORRHAGIC DYSENTERY, EXPERIMENT II

Lot no.	2 and 11	6 and 8	1 and 9	5 and 12	4 and 7
Treatments[a]	Basal	Basal+100 ppm of AA	Basal+200[b] ppm of AA	Basal+250[b] ppm of AA	Basal+175 ppm[c] NaA in the water
No. of pigs	20	19	20	19	19
Av. body wt., lb.					
Start	74.2	78.0	76.4	77.2	77.5
End	168.1	184.0	198.2	199.0	201.8
Av. daily gain, lb.					
Preexperimental[d]	1.11	1.18	1.15	1.18	1.16
Experimental period	1.06	1.26	1.46[f]	1.54[f]	1.61[e]
Av. daily feed intake, lb.	4.06	5.06	5.42	5.92	5.72
Feed/lb. gain, lb.	3.83	4.01	3.72	3.86	3.54
Mortality	6	5	4	0	0

[a] Experiment lasted for 11 weeks.
[b] Alternately provided for 4 weeks and withdrawn for 1 week during the experiment.
[c] Alternately provided for 5 days and withdrawn for 2 days during the experiment. 175 ppm NaA equivalent to 160 ppm AA.
[d] Average daily gains for a 1-month period prior to the start of the experiment.
[e] Significantly greater than the basal lot and the basal +100 ppm AA ($P<0.01$).
[f] Significantly greater than the basal lot ($P<0.01$).

TABLE 4. THE USE OF ARSANILIC ACID AS A PROPHYLACTIC AGENT IN HEMORRHAGIC DYSENTERY, EXPERIMENT III

Lot No.	7	3	6	4	5
Treatment[a]	Basal	Basal	Basal+100 ppm of AA	Basal+200 ppm of AA	Basal+250 ppm of AA
Number of pigs	20	20	20	20	20
Av. body wt., lb.					
Start	44.8	46.2	45.1	46.6	46.2
End	146.9	155.4	148.8	160.7	160.0
Av. daily gain, lb.					
Orally challenged	1.34	1.29	1.28	1.47	1.40
Contact challenged	1.14	1.32	1.08	1.38	1.56
Av.	1.25	1.30	1.18	1.43	1.48
Av. daily feed intake, lb.	4.03	4.20	3.88	4.38	4.41
Feed/lb. gain, lb.	3.36	3.35	3.32	3.16	3.04
Mortality	3	2	3	0	1

[a] Experiment lasted for 11 weeks.

did not appear to affect weight gains or mortality. For purposes of discussion the data for the two methods of infection are averaged. In this test the addition of 100 ppm AA to the diet did not increase weight gains or feed efficiency. Although dietary additions of 200 ppm or 250 ppm AA appeared to improve weight gains and feed efficiency, statistical analysis of the data did not show these differences to be significant ($P>0.05$).

The mortality rate was lower in the two groups receiving 200 ppm AA or 250 ppm AA. The one fatality which occurred in the group receiving 250 ppm AA did not exhibit the typical pathology associated with hemorrhagic dysentery, nor was *Vibrio coli* found in smears taken from the gastrointestinal tract.

On each weigh-day the lots were carefully observed for the presence or absence of scours. Some scouring was observed in all lots. But the greatest incidence of scours and the only bloody scours occurred in the control lots and in the lot receiving 100 ppm AA.

Average feed consumption expressed as a percent of body weight is given in table 5. The data from all three experiments are presented. In Experiments I and III there was little difference between the groups. This is not considered an atypical finding in pigs suffering from dysentery. However, pigs suffering with enteritis in which there is a febrile response, such as in *Salmonellosis*, generally show marked depression in appetite. The results of Experiment II show some depression in feed intake for the control group, but among the remaining groups there was little difference. In comparing the feed consumption figures from all three experiments with values given by the NRC, it appears that overall feed consumption was slightly depressed. Weight gains for the lots receiving 200 ppm or 250 ppm AA, or 175 ppm NaA were, however, about average.

Vibrio coli was isolated in all experiments from necropsied animals which showed gastrointestinal lesions typical of hemorrhagic dysentery. Early evidence for the etiological role of *Vibrio coli* in hemorrhagic dysentery was advanced by Doyle (1944). Subsequently, others have reported the presence of *Vibrio coli* in the intestinal tracts of pigs suffering from hemorrhagic dysentery (Boley *et al.*, 1951; Carpenter and Larson, 1952; Deas, 1960; Langham *et al.*, 1952; Roberts, 1956a). Doyle (1948) and Roberts (1956a, b) reported that feeding pure cultures of *Vibrio coli*, protected with gastric mucin, produced swine dysentery. Others have not produced the disease by feeding pure cultures but have succeeded in causing hemorrhagic dysentery when the gastrointestinal tracts of diseased pigs were fed to healthy ones (Boley *et al.*,

TABLE 5. AVERAGE DAILY FEED CONSUMPTION EXPRESSED AS A PERCENT OF BODY WEIGHT

Treatment	Basal	Basal+100 ppm of AA	Basal+200 ppm of AA	Basal+250 ppm of AA	Basal+175 ppm NaA in the water
Experiment I	3.47	3.51	3.23	3.33	3.24
Experiment II	3.35	3.86	3.95	4.29	4.10
Experiment III	4.21[a]	4.00	4.23	4.28	....

[a] Average of two basal lots.

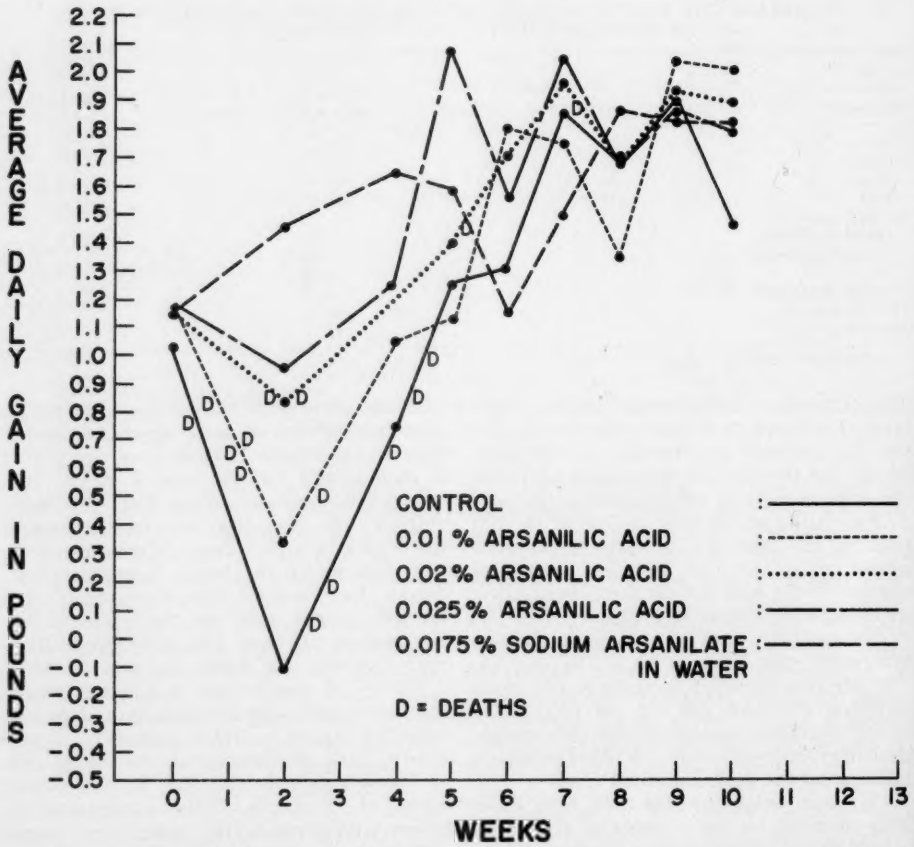

Figure 1. Average daily gain by weekly periods and time death occurred for pigs in Experiment II. Values represent the average daily gains for only those pigs surviving at each one-week interval.

1951; Deas, 1960; unpublished data, Kiggins, 1960). Reports by Carpenter and Larson (1952), Larson and Carpenter (1953), Doyle (1948), Deas (1960), and Roberts (personal communication, 1960) indicate that *Vibrio coli* is a normal inhabitant of the pig's colon. This suggests that some other factor plays a role in the etiology of hemorrhagic dysentery. A possible role for spirochetes has been suggested (Carpenter and Larson, 1952). It is also possible that a virus has an etiological role in this disease.

In figure 1 the average daily gain by weekly periods for those pigs in Experiment II are given. This is typical of the type of response observed in all experiments. The graph suggests that the difference in weight gain among the groups, as reported in the tables, resulted from the therapeutic effect of AA or NaA early in the experiment. Illustrated, also, is the marked mortality in the control group and the group receiving 100 ppm AA and the absence of mortality in the groups receiving 250 ppm AA or 175 ppm NaA.

Evidence presented in this paper indicates that untreated pigs, which survive the initial stages of hemorrhagic dysentery, appear to recover spontaneously. A possible role of arsanilic acid in the initial stages may be disease inhibition until the pig develops immunity. Certainly, in these experiments arsanilic acid appeared to have its most pronounced effect in the initial stages of the disease. The role of coccidiostats to suppress the disease, thus

permitting chickens to develop immunity to coccidiosis, has long been recognized. Obviously more research is needed to determine if such factors are operational in swine hemorrhagic dysentery.

Some investigators have observed evidence of toxicity in pigs fed arsanilic acid at 200 ppm of the diet from weaning to market (Frost *et al.*, 1955; Notzold *et al.*, 1956). It is noteworthy that in none of these experiments did any of the pigs exhibit signs of toxicity, even when fed arsanilic acid at 250 ppm of the diet for 11 weeks.

Summary

Data are presented from 3 experiments involving 277 pigs which were infected with hemorrhagic dysentery either through a natural outbreak or artificially. The treatment of this disease with 100 ppm arsanilic acid (AA), 200 ppm AA, or 250 ppm AA in the feed or 175 ppm sodium arsanilate (NaA) in the drinking water resulted in varying degrees of remission. In this series of tests 250 ppm AA in the feed or 175 ppm NaA in the water were the most effective in reducing the incidence of scours, lowering mortality, improving weight gains and improving feed efficiency. Feed consumption, while slightly lowered, was not sufficiently so as to preclude this medium as a route for medication.

Literature Cited

Boley, L. E., G. T. Woods, R. D. Hatch and R. Graham. 1951. Studies on porcine enteritis II. Experimental therapy with sulfathalidine, sulfamethazine, sodium arsanilate and bacitracin in a natural outbreak of swine dysentery. Cornell Vet 41:231.

Carpenter, L. E. 1951. The effect of 3-nitro-4-hydroxy phenyl arsonic acid on the growth of swine. Arch. Biochem. Biophys. 32:181.

Carpenter, L. E. and N. L. Larson. 1952. Swine dysentery. Treatment with 4-nitro and 3-nitro-4-hydroxy phenyl arsonic acids and antibiotics. J. Animal Sci. 11:282.

Deas, D. W. 1960. Observations on swine dysentery and associated vibrios. Vet. Record 72:65.

Doyle, L. P. 1944. A vibrio associated with swine dysentery. Am. J. Vet. Res. 5:3.

Doyle, L. P. 1948. The etiology of swine dysentery. Am. J. Vet. Res. 9:50.

Doyle, L. P. 1959. Dysentery. In Diseases of Swine, (H. W. Dunne, ed.) Iowa State University Press, Ames, Iowa.

Frost, D. V., L. R. Overby and H. C. Spruth. 1955. Studies with arsanilic acid and related compounds. J. Agr. Food Chem. 3:235.

Frost, D. V. and H. C. Spruth. 1956. Arsenicals in Feeds. In Symposium on Medicated Feeds. Medical Encyclopedia, Inc., New York, New York. p. 136.

Langham, R. F., R. Johnston, F. Thorp and J. Ritchie. 1952. Swine dysentery. Michigan State College Vet. 12:71.

Larson, N. L. and L. E. Carpenter. 1953. Studies on swine dysentery. The Hormel Institute Annual Report 1952–1953. p. 61.

Lubbehusen, R. E. 1956. Medicated feeds, some general comments. In Symposium on Medicated Feeds, (H. Welch and F. Martí-Ibáñez, ed.). Medical Encyclopedia, Inc., New York, New York. p. 9.

Notzold, R. A., D. E. Becker, F. B. Adamstone, S. W. Terrill and A. H. Jensen. 1956. The tolerance of swine to dietary levels of P-aminophenylarsonic acid. J. Animal Sci. 15:1234 (Abstr.).

Patrias, G. 1952. The use of arsonic compounds in practical feeding tests. Feed Age 2:32.

Patrias, G. 1953. Role of arsonics in animal feed. Proc. A.F.M.A. Nutrition Council 1953. p. 16.

Roberts, D. S. 1956a. Vibrionic dysentery in swine. The isolation of a vibrio from an outbreak in New South Wales. Australian Vet. J. 32:27.

Roberts, D. S. 1956b. Studies on vibrionic dysentery in swine. Australian Vet. J. 32:114.

Rosoff, I. S. and W. Abel. 1953. Bacitracin: Its Use in control and treatment of swine enteritis. Vet. Med. 48:369.

EFFECT OF EXOGENOUS TESTOSTERONE ON FRUCTOSE AND CITRIC ACID OF SWINE SEMEN [1]

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ADMINISTRATION of testosterone has been shown to restore fructose and, in some cases, citric acid levels in the semen of castrate bulls and rabbits, and to prevent the drop of these levels in a recently castrated animal if administered promptly, (Gassner *et al.*, 1952; Mann and Parsons, 1947). Mann and Parsons (1950) demonstrated a linear relationship between dose of testosterone and production of fructose and citric acid by the accessory glands of castrate rats. Mann (1954) stated that injection of testosterone produced increased levels of seminal vesicle fructose in intact rats. However, Gassner *et al.* (1952) found only a slight increase in level of fructose in semen of intact bulls following injection of 100 mg. of testosterone three times weekly for 6 weeks; Tyler (1955) found that testosterone injections produced no significant change in seminal fructose in humans in which endocrine testis function was not severely impaired.

Mann (1954) proposed that the seminal fructose level can be used as an indicator of testicular hormone activity, but in a later report (1956) recognized that wide variations in fructose occur in fertile males and that many factors other than testosterone affect fructose levels.

This study was initiated to determine the effects of level of exogenous testosterone on seminal fructose and citric acid concentration in boars and subsequently in the same animals as castrates.

Procedure

The experimental animals were six boars and two castrates, 2 years of age, weighing approximately 700 lb., and trained to serve an artificial vagina (AV) mounted in a dummy.

Semen was collected in an AV twice weekly at 3 or 4-day intervals. Strained semen volume, rate and percent sperm motility, sperm concentration and initial fructose concentration were determined as previously described (Pace *et al.*, 1961). Citric acid was determined by the Furth-Herrmann reaction (Saffran and Denstedt, 1948). Semen was diluted 1:4 with normal saline before addition of trichloracetic acid for precipitation of protein and sperm. Colorimetric determinations of fructose and citric acid were made in triplicate.

The six boars were used in the first phase. Following a 3-week pretreatment period in which the semen of each boar was characterized, intramuscular injections of testosterone propionate in sesame oil were initiated. Dose levels of 7.5, 37.5, and 187.5 μg. of testosterone propionate per pound of body weight per day were used in periods one, two, and three, respectively. Within each period the hormone was administered three times weekly. During each period (2 weeks), four semen collections were obtained from each boar. After the third period, twice weekly semen collections were continued until fructose concentration in two consecutive ejaculates was within the range of the pretreatment level of the individual. As each boar reached this level, he was castrated and semen collections continued until he was unable to serve the AV on 2 consecutive collection days.

At this time, the second phase of the experiment was initiated by administering testosterone to these recent castrates at the lowest dose level (7.5 μg. per lb. body weight per day). If the castrate failed to serve during a two-week interval at this level, the next level was initiated. Each level at which the animal ejaculated was continued until four collections were obtained, then the next higher hormone level was administered. Following the completion of the highest level of treatment, collections were continued until the

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TABLE 1. MICROGRAMS OF SEMINAL FRUCTOSE PER ML. OF SEMEN PRODUCED BY INDIVIDUAL ANIMALS IN EACH TREATMENT PERIOD

	Periods[a]								
	Precastration					Postcastration			
Boar	0	1	2	3	Av.	1	2	3	Av.
2	341[b]	331	355	643	418	343	385	350	325
6	53	123	208	415	200	17[c]	20	117	51
12	289	195	275	627	346	20	9	72	38
19	366	453	473	866	540	391	159	223	258
20[d]	249	346	392	499	372	...	....	....	....
21	733	1046	1388	2043	1302	...	1658	1618	1638
Period average	339	419	515	849	....	...	426	478	....

[a] Each animal received 0, 7.5, 37.5, and 187.5 μg. of testosterone propionate per pound of body weight per day in periods 0, 1, 2, and 3 respectively.
[b] Each value represents the mean of 4 collections.
[c] Only one collection was obtained from this boar in this period.
[d] Died after castration.

animals failed to serve the AV for two consecutive attempted collections.

Two animals that had been castrated two months prior to initiation of therapy received testosterone at the 37.5 μg. per lb. body weight per day level for 2 weeks. Since they refused to serve they were given two injections at a level of 375 μg. Then they were continued on therapy at the 37.5 μg. level for 2 weeks, followed by 187.5 μg. for 4 weeks, and finally, 375 μg. for 2 weeks.

Analysis of variance, correlation analyses and multiple range tests (Duncan, 1955) were used for statistical interpretation of the data.

Results and Discussion

Seminal Fructose. The effect of exogenous testosterone on fructose concentration in boar semen during the precastration period is summarized in table 1. Fructose was increased in four of six boars at the lowest dose level, five of the six at the second level, and all at the third dose level. The fructose levels in periods one, two and three differed significantly from each other, but the level in period one did not differ significantly from the pretreatment control level. Fructose levels increased rapidly following each increase in hormone dose; the first of four collections in each period was 93% of the mean for that period. This finding is consistent with that of Rudolph and Samuels (1949) in rats.

Although all boars responded to testosterone treatment, greater variation existed between boars than between treatments (table 2). The significant boar by treatment interaction ($P<.01$) is characterized by the observation that the boar with the highest pretreatment level gave the largest absolute increase in fructose, but a smaller percentage increase than the lowest boar.

An average of 34 days (range 20–45) intervened following completion of testosterone injections at the 187.5 μg. level before fructose concentration returned to pretreatment level, indicating a slow testosterone utilization or a slow gland regression.

The boars were castrated upon return to the pretreatment fructose levels. Fructose levels increased in five of six boars in the collection obtained 2 days after castration (an average increase of 100 μg. or 27% over pretreatment level). Since none of these ejaculates contained any sperm, this increase may have been due to absence of sperm which would have rapidly taken up significant amounts of fructose at the time of ejaculation. By 16 days after castration (the last collection period that any boar served the AV) fructose levels had declined to nearly zero.

After each boar had failed to serve the AV for two consecutive times, testosterone injections were initiated at 7.5 μg. followed in sequence by the two higher levels. The fructose response of the five castrates (one died

TABLE 2. ANALYSIS OF VARIANCE OF SEMINAL FRUCTOSE LEVEL IN BOARS

Source of variance	df	M.S.	F
Total	95	.....	....
Boars	5	2,557,309	19.97**[a]
Level	3	1,123,071	8.77**[a]
B x L interaction	15	128,049	4.62**
Residual	72	27,705	....

** $P<.01$.
[a] Significance tested against B x L interaction.

shortly after castration) to the three dose levels is summarized in table 1. The orderly increase in fructose with increasing hormone level which was noted in the animals prior to castration was absent in the castrates. The lowest dose brought four of the five animals back to service within 3 to 9 days. Although one served only once during the two-week period, all animals served at the 37.5 and 187.5 μg. testosterone levels. The dose which restored the animal to service usually restored fructose concentration to approximately the pretreatment control level, but subsequent higher testosterone levels resulted in no increase in fructose.

Exogenous testosterone at the 375 μg. level was required to restore sexual activity and fructose levels in two animals which had been castrated for 2 months while 37.5 μg. were sufficient to restore the recent castrates to service. Fructose concentration was very low (22–65 μg. per ml.) in the collections obtained following the initial 375 μg. testosterone doses. However, following therapy at the 37.5 and 187.5 μg. dose levels, concentrations of 315 and 984 μg. per ml. of fructose were obtained from the two animals. Subsequent therapy at 375 μg. of testosterone resulted in 376 and 1296 μg. fructose per ml., respectively, for the two animals.

All castrates continued to serve for an average of 19 days (range 13–25) after testosterone was discontinued. In general, fructose levels had not declined appreciably by the time the animals were unable to serve.

These data indicate that the seminal fructose level of recent castrates cannot be used as a quantitative estimate of the amount of testosterone injected. Failure of increased doses of testosterone to bring about increased fructose in the recent castrates as it did in boars, and the larger dose required to maintain service following the two month interval from castration to initiation of therapy indicate that changes not reversible by testosterone took place following castration.

Seminal Citric Acid. The mean pretreatment citric acid level of the six boars was 1770 μg. per ml. and was not changed significantly by increasing levels of testosterone. There were significant differences between boars, but the approximately two-fold difference between the highest and lowest pretreatment boar means (2520 and 1180 μg. citric acid per ml., respectively) was small in relation to the 14-fold difference between the highest and lowest pretreatment fructose averages. Fructose and citric acid levels in the precastration period showed little correlation (r=0.04), however, the boar with the lowest fructose level also had the lowest citric acid level.

In the recent castrates, citric acid levels were not increased by increasing hormone dose above that required to restore the animals to service. Precastration and postcastration citric acid levels were not as closely related within individuals as were fructose levels. In two cases during the postcastration period low citrate levels accompanied reduced fructose levels. In one castrate in which fructose level was much lower during the entire postcastration therapy period than during precastration, citric acid level during this period was only one-third of the precastration level. In the initial ejaculates obtained from the two animals in which two months elapsed between castration and therapy, the concentration of citric acid was only 17% of the 3072 μg./ml. obtained following extended therapy. These results indicate that citric acid level was depressed only when a marked depression of fructose reflected a severe inhibition of accessory gland function.

Sperm Motility, Concentration and Semen Volume. Sperm motility, concentration, volume and total sperm per ejaculate did not change significantly during any of the three treatment periods. In two of the three boars not castrated within 4 weeks after the end of therapy, a 36% reduction in total sperm was noted during the fourth to sixth week after the end of therapy. This 10 weeks from initiation of therapy until effects on sperm production were noted is comparable to that reported by Charney (1959) for humans.

Histological examination confirmed that exogenous testosterone had impaired spermatogenesis, as indicated by reduced numbers of spermatocytes and spermatids and an indication of cellular disarrangement in some tubules. The degree of damage varied between animals but in no case was spermatogenesis absent in any tubule. The results of this relatively short period of therapy can be compared with the observed marked depression in spermatogenesis in cattle following 12 weeks of testosterone therapy (Meinecke & McDonald, 1961), and the reported complete degeneration of the seminiferous epithelium following 3 to 4 months of testosterone treatment in humans (Joel, 1960).

In the first collection after castration, the volume of seminal fluid was 85% of the precastration semen volume (237 ml.,); and the

volume decreased to 46% by 16 days post-castration. After initiation of testosterone therapy, volume of seminal fluid obtained from the castrates at the first dose level was 49% of precastration and increased only to 62% in the period following the highest dose level.

Libido. Although no objective measure of libido was made, there was no indication that libido of intact boars was affected by testosterone treatment. All castrates served the AV readily only 2 days after castration despite marked swelling of the scrotal area. Within 5 to 19 days after castration, all had refused to serve the AV. This early failure of swine to serve differs from the finding of Gassner *et al.* (1952) that sex drive in bulls was not affected during the first 3 months after castration, although fructose disappeared from the semen in only 1 to 2 weeks.

Hormone therapy at 7.5 μg. restored three of the five recent castrates to regular service and 37.5 μg. restored the other two to service; 187.5 were required to maintain regular service in the two animals that had been castrated two months prior to initiation of therapy.

Strong sexual desire, as indicated by mounting the dummy, usually returned 3 to 4 days prior to ability to achieve erection. This pattern of behavior was also evident when testosterone was withdrawn. Inability to achieve erection always preceded loss of desire. Inability to serve also preceded loss of accessory gland function as indicated by maintenance of fructose, citric acid and semen volume in the last collection obtained.

Summary and Conclusions

Three levels of testosterone propionate in oil (7.5, 37.5 and 187.5 μg. per pound of body weight per day) were administered in sequence to six boars and later to the same animals as castrates. Two additional castrates received three levels of testosterone beginning 2 months after castration.

Each increase in testosterone level increased the seminal fructose concentration in boars. However, pretreatment fructose levels differed widely between boars; fructose response to added testosterone was not uniform and was dependent upon pretreatment level. All animals served the artificial vagina 2 days after castration, but ceased to serve by 19 days after castration. Testosterone injections, beginning 8 to 22 days after castration, restored the castrates to service; however, the fructose level of each animal was usually restored to approximately the pretreatment level of the animal as a boar and was not increased by higher levels of testosterone. More testosterone was required to restore castrates to service when 2 months intervened between castration and initiation of therapy and an increase in dose above the level which restored the castrates to service resulted in increased seminal fructose.

Seminal citric acid levels were not changed by testosterone injections in boars or castrates.

Sperm concentration, motility, and semen volume were not affected during testosterone injections. Histological examination of testes taken 4 to 6 weeks after the end of therapy indicated impairment of spermatogenesis. The volume of seminal fluid produced by castrates was 50 to 60% of that produced by boars.

Literature Cited

Charney, C. W. 1959. The use of androgens for human spermatogenesis. Fert. and Ster. 10:557.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics 11:1.

Gassner, F. X., H. J. Hill and L. Sulzberg. 1952. Relationship of seminal fructose to testis function in domestic animals. Fert. and Ster. 3:121.

Joël, Charles A. 1960. The spermiogenetic rebound phenomena and its clinical significance. Fert. and Ster. 11:384.

Mann, T. 1954. The Biochemistry of Semen. John Wiley and Sons, Inc., New York, N. Y.

Mann, T. 1956. Male sex hormone and its role in reproduction. Rec. Prog. Hormone Res. 12:353.

Mann, T. and Ursula Parsons. 1947. Effect of testicular hormone on the formation of seminal fructose. Nature 196:294.

Mann, T. and Ursula Parsons. 1950. Studies on the metabolism of semen. 6. Role of hormone, effect of castration, hypophysectomy and diabetes. Relation between blood glucose and seminal fructose. Biochem. J. 46:440.

Meinecke, C. F. and L. E. McDonald. 1961. The effect of exogenous testosterone on spermatogenesis of bulls. Am. J. Vet. Res. 22:209.

Pace, H. B., R. L. Murphree and E. W. Hupp. 1961. Effects of prenatal gamma radiation on testicular morphology and function in swine. Am. J. Vet. Res. 22:406.

Rudolph, G. G. and L. L. Samuels. 1949. Early effects of testosterone on the seminal vesicles of castrate rats. Endocr. 44:190.

Saffran, M. and O. F. Denstedt. 1948. A rapid method for the determination of citric acid. J. Biol. Chem. 175:849.

Tyler, E. T. 1955. Seminal fructose studies in infertility. Fert. and Ster. 6:247.

UTILIZATION OF CHOPPED, WAFERED, AND PELLETED NATIVE MEADOW HAY BY WEANED HEREFORD CALVES [1]

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NUMEROUS workers have studied the effects of pelleting on the utilization of alfalfa hay and certain other roughages for ruminant animals (Neale, 1953; Blaxter and Graham, 1956; Webb *et al.*, 1957; Weir *et al.*, 1959; Lindahl and Reynolds, 1959). The feeding value of alfalfa wafers for dairy cows was investigated by Jones *et al.* (1958) and for growing sheep by Meyer *et al.* (1959b). There are, however, limited data available on the feeding value of meadow hay as influenced by different methods of preparation.

The refusals of coarsely chopped meadow hay generally contain higher amounts of crude protein and lower amounts of fiber than the hay initially offered. This relationship is probably due to physical properties rather than to a particular preference by the animal for certain portions of the hay. Since pelleting greatly reduces hay refusals it could enable an animal to consume a higher quality diet in the case of meadow hay.

The purpose of the work reported in this paper was to compare the performance of weaner calves fed coarsely chopped, wafered, or pelleted mountain meadow hay as their sole diet and to make digestibility comparisons between the three forms of hay.

Experimental Procedure

Feeding Trial. Eighteen steer and 12 heifer calves were stratified by weight and randomly allotted to three lots of 10 animals each. Six steers and four heifers were assigned to each lot. Each lot was group fed (*ad libitum*) either coarsely chopped, wafered, or pelleted meadow hay as their sole diet. The different forms of hay for each respective lot were weighed into sheltered mangers daily and the refusals were weighed weekly. Water, salt, and a salt: bonemeal mix were available to the animals at all times. During the 126-day study, individual weights were taken at periodic intervals following overnight restriction from feed and water. Initial and final weights were averages of two consecutive day weights.

All hay used in the experiment was from the same meadow on the Squaw Butte Station. The hay consisted primarily of rush (*Juncus* spp.) and sedge (*Carex* spp.) with minor amounts of grass and native clover (*trifolium* spp.). The hay was harvested in early July, coarsely chopped (approximately 2-in. lengths), and stored. A portion was processed into 4-in. wafers by a commercial feed plant. The fineness of the hay processed into wafers was similar to that of the chopped hay. The portion fed as pellets was ground through a ⅛ in. screen and processed into ⅜ in. pellets. Density of the chopped hay was reduced slightly more than three times as result of wafering and more than seven times by pelleting. The chemical composition of the three forms of hay used in the feeding and digestion trials is shown in table 1.

Digestion Trial. At the end of the feeding trial, three uniform steers from each lot were placed in individual feeding stalls and kept on their respective diets during the digestion trial. All diets were fed at a level calculated to provide approximately 120% of maintenance. A 10-day preliminary period and a 5-day total collection period were used. Aliquots amounting to 10% of the daily fecal output were composited over the 5-day period. Composite samples were obtained for each diet from daily samples taken during the collection period.

Gross energy was determined by an oxygen bomb calorimeter. Cellulose was determined by the method of Crampton and Maynard (1938) and other determinations were made according to standard A.O.A.C. (1955) procedures.

Results and Discussion

Feeding Trial. The higher cellulose and energy values and the lower crude protein con-

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TABLE 1. CHEMICAL COMPOSITION[a] OF EXPERIMENTAL DIETS

Constituent	Form of hay		
	Chopped	Wafered	Pelleted
Ash, %	11.05	10.8	12.1
Cellulose, %	30.8	32.4	29.1
Crude protein, %	8.9	7.0	9.5
Gross energy (T/lb.)	1.90	1.94	1.90

[a] Dry matter basis.

tent of the wafered hay (table 1) may be partially explained by a considerable loss of the finer, leafier particles and possibly some dirt or foreign material during the wafering process. The portable "foragizer" used in wafering was located outside and high winds prevalent during the operation were assumed responsible for the losses. The protein content of the pelleted hay was slightly higher than that of the chopped hay (table 1).

Pellet-fed calves gained at a significantly faster rate ($P<0.01$) than those fed chopped or wafered hay (table 2). The difference in gain of animals fed chopped and wafered hay was not significant. The lower crude protein content of the wafered hay (table 1) may explain why calves on this diet gained slightly less. Processing the hay into wafers increased consumption by a small margin. Meyer *et al.* (1959b) reported slight increases in feed intake and rate of gain as result of wafering alfalfa hay for lambs. These workers concluded, however, that the main advantage in wafering hay was probably the improvement in physical handling characteristics.

Hay consumption was significantly higher ($P<0.01$) and refusals significantly lower ($P<0.01$) for calves receiving pelleted hay compared to those receiving either chopped or wafered hay. Pelleting meadow hay reduced dust and eliminated interference of foxtail barley (*Hordeum jubatum* L.) which is commonly found in meadow hay and can, in some instances, reduce intake through mechanical irritation to the animals.

Feed conversion favored the calves receiving pelleted hay. This was more noticeable when the calculations were based on total hay fed rather than on the amounts actually consumed.

TABLE 2. RESULTS OF FEEDING TRIAL[a]

Item	Form of hay		
	Chopped	Wafered	Pelleted
	lb.	lb.	lb.
Initial wt.	358	357	360
Daily gain	0.37	0.30	0.71[b]
Daily hay fed	12.14	11.84	12.65
Daily hay cons.	9.90	10.09	12.29[b]
Daily hay refused	2.24	1.75[c]	0.36[d]
Hay cons./lb. gain	26.8	33.7	17.3
Hay fed/lb. gain	32.8	39.5	17.8

[a] Average of 10 calves per treatment.
[b] Significantly higher ($P<0.01$) than calves fed chopped or wafered hay.
[c] Significantly lower ($P<0.01$) than calves fed chopped hay.
[d] Significantly lower ($P<0.01$) than calves fed chopped or wafered hay.

Digestion Trial. Average amounts of the daily hay refusals during the digestion trial as well as their cellulose and crude protein contents are presented in table 3. When feed offered was limited to a level slightly above maintenance during the digestion trial the differences in amount of hay refused among diets were not as large as those which occurred during the feeding trial (table 2).

TABLE 3. AMOUNT AND COMPOSITION[a] OF HAY REFUSALS DURING THE DIGESTION TRIAL[b]

Item	Form of hay		
	Chopped	Wafered	Pelleted
Daily hay refused, lb.	0.49	0.56	0.24
Cellulose content, %	27.5	30.8	30.5
Crude protein content, %	11.3	8.0	9.0

[a] Dry matter basis.
[b] Average of three calves per treatment.

Cellulose values were lower and crude protein contents were higher in both chopped and wafered hay refusals than in the feed as initially offered. These analyses would suggest that steers fed either coarsely chopped or wafered hay actually consumed a less nutritious diet than was offered. This relationship is in contrast to observations on sheep fed long hay as reported by Reynolds and Lindahl (1960). Conversely, pelleted hay refusals were higher in cellulose and lower in crude protein than the pellets initially fed. This would indicate that processing the hay into pellets not only reduced quantity of refusal but, perhaps more important, increased quality of intake.

Digestion coefficients were reasonably comparable between replications for each form of hay; however, with the number of animals used in the trial as designed, the differences were not sufficient to show significance by analysis of variance. The trends noted in apparent digestibility of dry matter, cellulose, and energy were higher in the chopped and

TABLE 4. APPARENT DIGESTION COEFFICIENTS[a] FOR EXPERIMENTAL DIETS

Constituent	Form of hay		
	Chopped	Wafered	Pelleted
	%	%	%
Dry matter	57.4	56.8	51.4
Ash	36.7	34.7	34.7
Cellulose	63.9	65.0	53.4
Crude protein	50.8	48.4	51.4
Gross energy	55.9	55.6	49.3

[a] Average of three calves per treatment.

wafered hay than in the pelleted hay (table 4). On the other hand, apparent digestibility of crude protein was slightly higher in the pelleted hay than in either chopped or wafered hay. This might be partially attributed to the higher level of protein in the pelleted hay as compared to chopped or wafered hay. The trends noted in fiber (cellulose) and protein digestibility for the chopped and pelleted diets are in close agreement with those reported by Wallace and Hubbert (1959). These results are also similar to those found by Meyer *et al.* (1959a) during a study comparing alfalfa fed in chopped and pelleted forms.

Reynolds and Lindahl (1960) observed that poor-quality long hays were consistently higher in digestibility of gross nutrients when conventional "as consumed" digestion coefficients were used. However, when coefficients were calculated on the basis of the nutrients offered, the pelleted hays were higher in digestibility. These workers reported refusals of 9.5 to 16.2% of long hays fed as compared with no refusal of the pelleted hay diets which, to a large extent, explained the reversal in digestibility values that occurred when the "as fed" method was used. The calculation of digestion coefficients on the basis of nutrients offered in this trial would not alter the digestibility trends established by the usual method of calculation since differences in amount of hay refused among diets were so small.

TABLE 5. ENERGY AND TDN CONTENTS[a] OF EXPERIMENTAL DIETS

Constituent	Form of hay		
	Chopped	Wafered	Pelleted
Gross energy, Kcal/Kg	4190	4268	4200
Digestible energy, Kcal/Kg	2359	2379	2074
TDN, %[b]	53.6	53.9	46.9

[a] Dry matter basis.
[b] Calculated according to Swift (1957). (2,000 Kcal digestible energy=1 pound TDN).

Energy and TDN values for the experimental diets are presented in table 5. Digestibility energy and TDN values for both chopped and wafered hays were higher than for the pelleted hay.

Summary

Native meadow hay was fed as the sole diet in coarsely chopped, wafered, and pelleted forms to weaned Hereford calves. Hay consumption and rate of gain were significantly increased while hay refusals were significantly decreased as a result of pelleting.

Apparent digestibility of nutrients among the three forms of hay was not significantly different. Digestibility trends did, however, indicate a depression in dry matter, cellulose, and energy digestion and an increase in protein digestion as a result of pelleting meadow hay.

Refused portions of chopped and wafered hays were consistently higher in crude protein and lower in cellulose content than these hays as offered. Conversely, pelleted hay refusals were higher in cellulose and lower in crude protein than the pellets initially fed.

Literature Cited

A.O.A.C. 1955. Methods of analysis. Association of Official Agricultural Chemists. Washington, D. C.

Blaxter, K. L. and N. McC. Graham. 1956. The effect of the grinding and cubing process on the utilization of energy of dried grass. J. Agr. Sci. 47:207.

Crampton, E. W. and L. A. Maynard. 1938. The relation of cellulose and lignin content to the nutritive value of animal feeds. J. Nutr. 15:383.

Jones, I. R., B. S. Magill and R. G. Peterson. 1958. Baled, wafered, and pelleted hay. Ore. Agr. Exp. Sta. Bul. (Unnumbered).

Lindahl, Ivan L. and P. J. Reynolds. 1959. Effect of pelleting on the chemical composition and digestibility of alfalfa meal. J. Animal Sci. 18:1074.

Meyer, J. H., R. L. Gaskill, G. S. Stoewsand and W. C. Weir. 1959a. Influence of pelleting on the utilization of alfalfa. J. Animal Sci. 18:336.

Meyer, J. H., W. C. Weir, J. B. Dobie and J. L. Hull. 1959b. Influence of the method of preparation on the feeding value of alfalfa hay. J. Animal Sci. 18:976.

Neale, P. E. 1953. Alfalfa cubes for fattening lambs and wethers. N. Mex. Agr. Exp. Sta. Bul. 398.

Reynolds, P. J. and Ivan L. Lindahl. 1960. Effect

of pelleting on the digestibility of hay by sheep. J. Animal Sci. 19:873.
Swift, R. W. 1957. The caloric value of TDN. J. Animal Sci. 16:753.
Wallace, Joe D. and Farris Hubbert, Jr. 1959. Response of beef cattle to pelleted and coarsely chopped mountain meadow hay with digestibility comparisons. J. Animal Sci. 18:1177 (Abstr.).
Webb, R. J., G. F. Cmarik and H. A. Cate. 1957. Comparison of feeding three forages as baled hay, chopped hay, hay pellets, and silage to steer calves. J. Animal Sci. 16:1057 (Abstr.).
Weir, W. C., J. H. Meyer, W. N. Garrett, G. P. Lofgreen and N. R. Ittner. 1959. Pelleted rations compared to similar rations fed chopped or ground for steers and lambs. J. Animal Sci. 18:805.

GAS-TIGHT CANNULA FOR RUMEN FISTULA[1]

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FISTULATED ruminants have played an important role in research concerning the rumen and ruminant nutrition. A cannula tightly sealed in a fistula would insure a cleaner, more easily cared for fistulated ruminant, and maintain a more normal rumen environment.

This report deals with a liquid and gas-tight fistula-cannula, which can be made easily from inexpensive materials. This cannula was developed primarily for the fistula of an isolated rumen pouch (Komarek *et al.*, 1960), however, it has proven equally satisfactory for access to the entire rumen.

Materials and Methods

A one liter polyethylene bottle (figure 1) and a rubber compression plug designed for vacuum bottles were the materials used to make the cannula. The upper part of the bottle was cut off in such a way as to include the neck and part of the flange of the top of the bottle (figure 1-b). With the polyethylene cap in place, the upper part of the cap and neck of the bottle were cut off, leaving 2 or 3 threads and a threaded ring (figure 1-a). The bottom of the bottle was also cut off (figure 1-c) and a large polyethylene ring (washer) was made from it. The bottom of a polyethylene bottle does not have uniform thickness and is for the most part thicker than the rest of the bottle. Its thickness was reduced with a power sander so that it became uniform and flexible. In some cases the opening in the neck of the cannula was rebored so that the vacuum bottle stopper would fit. The finished parts of the cannula are shown in figures 2 and 3 (exploded and assembled).

Fistula techniques have been described by Markowitz (1954) and Dougherty (1955). No attempt will be made to describe in detail the operative procedure except for those manipulations which are important in the installation of this particular cannula.

An incision was made a few inches posterior to the last rib to gain access to the rumen. After the rumen had been exposed an incision was made in the rumen just large enough for passage of the flange of the cannula. The incision was positioned posterior to the terminal section of the left ruminal artery and just anterior to the dorsal branch of the right ruminal artery which extends to the left side of the rumen. The cannula was inserted into the rumen and four interrupted sutures which were previously sewed into the outer edge of the cannula flange were stitched through the rumen and tied. A Murphy purse string suture was sewed around the edge of the ruminal incision and was drawn tight and tied. This suture technique tends to curl the edges of the incision inward insuring that the rumen serosa will come in contact with the cut edges of the muscle layers and skin.

An incision was then made in the upper left flank, anterior to the tuber coxae, caudal to the lumbar costal arch and just ventral to the fourth lumbar vertebra. This incision in the skin was made just large enough for the neck of the cannula to be forced through. The fascia was incised, the muscle fibers of each layer were spread by blunt dissection and the peritoneum was then incised. To facilitate forcing the cannula through the incison, a cone-shaped piece of aluminum was machined so that it could be screwed on to the top of the cannula before forcing it through the side of the animal and a threaded handle was made so that it could be inserted through the incision and screwed into the top of the cone (figure 4). Thus the cone and cannula were held firmly and the tissues were stretched over the ridge on the neck of the cannula with relative ease by working these layers over the cone with a scalpel handle. The peritoneum, the muscle layers and the skin were forced over the ridge on the cannula which lies just below the threads on the neck of the cannula. Penicillin in oil (300,000 units) was then spread under the ridge of the cannula. The polyethylene ring was slipped over the neck of the cannula and the threaded ring made from the cap was used as a nut and tightened forcing the ring against the ridge giving me-

[1] Scientific Article No. A 913, Contribution No. 3256 of the Maryland Agricultural Experiment Station, Department of Animal Husbandry.

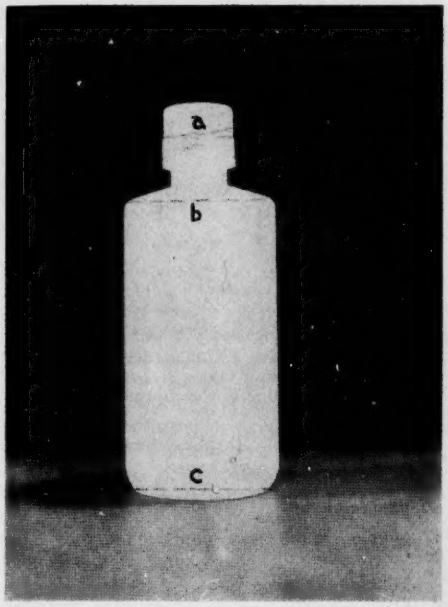

Figure 1. The cannula is made from a one-liter polyethylene bottle by cutting at a, b, and c.

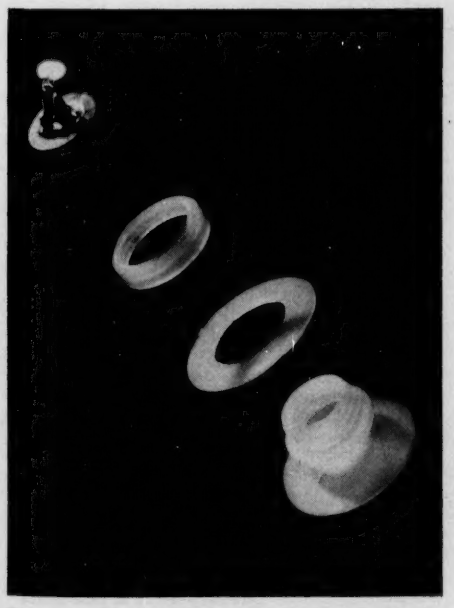

Figure 2. The finished parts of the cannula in an exploded view.

chanical support to the cannula from the outside. The initial incision in the side of the animal was then closed.

Results and Discussion

This type of cannula has been used on 20 sheep with rumen pouch preparations and on two with ordinary fistulas. It has provided a clean, neat, gas and liquid tight cannula. It is readily sealed and opened by merely flipping the lever on the compression plug.

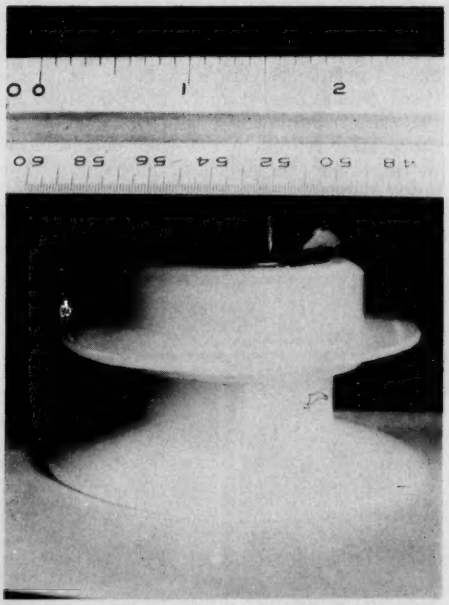

Figure 3. The assembled cannula (top scale in tenths of an inch).

The tightness of the cannula has been verified by the audible release of rumen gases which occurred when the cannula was opened. In addition, experimental bloat has been produced in sheep fitted with this cannula. The neck of the cannula protrudes only ½ in. from the side of the animal and thus is rarely subjected to mechanical disturbance by the animal. The entire cannula with plug weighs only 38 gm. Figure 5 shows a Hampshire ewe with a cannulated rumen pouch preparation. This photograph was taken three months subsequent to the operation and the cannula remained gas and liquid tight over this period.

The rigidity of the cannula and the relative flexibility of the scar tissue make it impossible for this cannula to be permanently gas and liquid tight. In most cases, after 3 to 4 months, a very small amount of rumen fluid was forced between the cannula and the scar ring which was formed around the neck of the cannula, but the preparation was still able to hold gas pressure. Even after 6 months, the amount of fluid forced out is not sufficient to require much attention to keep the animal clean and neat in appearance.

The size of the flange on the cannula is a compromise between the mechanical strength which a larger flange would give and a minimal incision of the rumen. Fortunately, the flange on the polyethylene bottle is much larger than is needed and if a modification in the size of the flange is desired, there still is the possibility that a one liter polyethylene bottle would be sufficient. There are also larger polyethylene bottles with this type of construction, which could easily be adapted to larger ruminants.

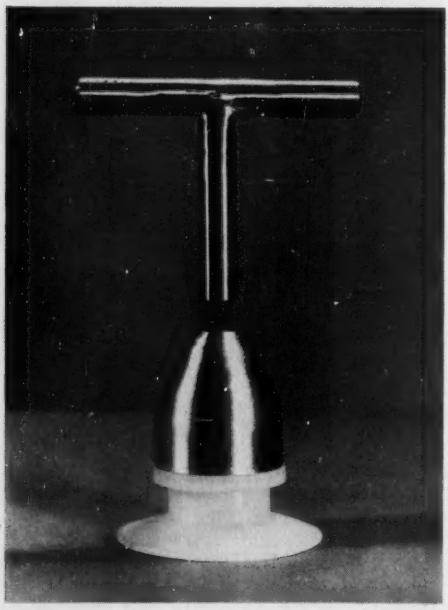

Figure 4. Cone and handle screwed to the top of the cannula to facilitate the introduction of the cannula.

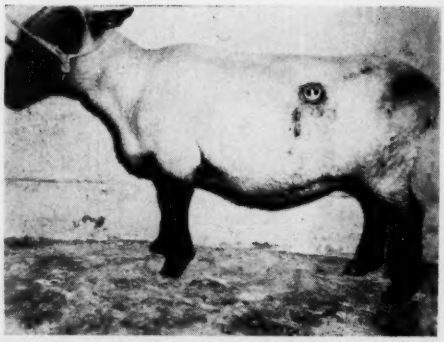

Figure 5. Ewe with cannulated rumen pouch. This photograph was taken 3 months after the introduction of the cannula.

The vacuum bottle compression stopper can be modified, so that pressure readings, infusing or sampling can be done through the stopper by replacing the central shaft of the stopper with a tube so constructed that compression of the rubber segment is still possible.

Although this cannula preparation has been used with sheep, the basic technique is applicable to all ruminants if the skin and muscle layers will fit under the ridge on the neck of the cannula and if the size of the cannula is ample for the work planned.

Summary

A cannula has been perfected which can be made from inexpensive materials and which will give a satisfactory gas and liquid tight seal. The cannula described will permit the entrance of a tube of up to 22 mm. in diameter. This cannula has been used in sheep, but the same technique could conceivably be used for larger ruminants.

Literature Cited

Dougherty, R. W. 1955. Permanent stomach and intestinal fistulas in ruminants: some modifications and simplifications. Cornell Vet. 45:331.

Komarek, R. J., E. C. Leffel, W. H. Brown and K. R. Mason. 1960. Technique for establishment of a rumen pouch. J. Appl. Physiol. 15:181.

Markowitz, J. 1954. In collaboration with J. Archibald and H. G. Downie. Experimental Surgery, Including Surgical Physiology. (3rd ed.) Williams and Wilkins, Baltimore, Md.

EFFECTS OF FOLIAR APPLICATION OF UREA ON THE YIELD AND NUTRITIVE VALUE OF SOME GRASS HAYS [1]

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PUBLISHED data show that soil applications of nitrogen increase the yield and protein content of grasses, but have little, if any, effect on the TDN content or digestibility of the dry matter. There is an increased apparent digestibility of protein which is a result of an increased protein content (Poulton *et al.*, 1957; Poulton, 1958; Colovos *et al.*, 1958; Barth, 1958; Markley *et al.*, 1959). However, Belasco *et al.* (1958) reported that applying urea to the foliage of growing grasses greatly increased the digestibility of the cellulose, dry matter and protein of the hay as measured by *in vitro* procedures.

The experiments reported here were planned to evaluate further the effects of foliar application of urea on the yield, chemical composition, nutritive value and rate of uptake of urea applied on certain grass hays.

Experimental Procedures

The experimental procedures are briefly described, full details can be found in the reports by Mitchell (1958) and Merrill (1959). The data were subjected to analysis of variance and comparisons between pairs of means were made by Duncan's (1955) multiple range test.

Foliar Application of Urea

Urea was sprayed on the forage by a jeep-mounted sprayer which was calibrated to deliver 30 gal. of water per acre. The spray solutions contained approximately 2 to 3 lb. of urea per gal. of water depending upon the amount to be applied. For applications much greater than 60 lb. of urea per acre, the area had to be covered more than once.

When less than 100 lb. of urea were applied per acre, "du Pont Nu Green" was used. When more than 100 lb. of urea were applied per acre, du Pont crystalline urea,[5] a low biuret preparation, was used as a precaution against leaf burn. Both urea preparations contained about 45% nitrogen. A combination wetting and adhesive agent, "du Pont Spreader-Sticker", was added at the rate of 15 drops per gal. of solution as recommended by the manufacturer.

The influence of foliar applications of urea on yield of forage and rate of uptake of urea was studied in the field and greenhouse, respectively. The urea solutions were applied to the plants with either a sprinkling can or a small spray apparatus and the same sources of urea and "spreader-sticker" mentioned above were used.

Hays

Reed Canarygrass (*Phalaris arundinacea*). An aftermath growth of a nearly pure stand of reed canarygrass was available on land that had not been fertilized for 5 years. The grass was approximately 6 to 8 in. high at the time of spraying. One half of the 3-acre field was sprayed with urea at the rate of 90 lb. per acre on August 20, 1957. Both the treated and untreated grasses were cut 7 days later.

Timothy Hay (*Phleum pratense*). A field of timothy of approximately 3 acres was clipped on May 10, 1958 and the cut forage removed. The area was divided into six plots of about 0.5 acre each. Three plots were used to produce early-cut hay and the other three plots were left for late-cut hay. For the early-cut hay the following treatments were applied: (1) unfertilized, (2) soil fertilized with urea at the rate of 52 lb. per acre on May 21 plus 70 lb. per acre on May 26 or a total of 122 lb. per acre, and (3) urea sprayed or foliar application of 122 lb. of urea per acre on

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[5] Courtesy of I. J. Belasco, Polychemicals Division, E. I. duPont de Nemours and Co., Inc., Wilmington, Delaware.

June 3. All the plots for early-cut hay were cut June 12. The three plots of late-cut hay were treated as follows: (1) unfertilized, (2) soil fertilized with urea at the rate of 267 lb. per acre on June 25, and (3) the urea sprayed or foliar application of 251 lb. of urea per acre on July 9. All the plots of late-cut timothy were cut July 16.

All the hays were partially field-cured, baled and the drying completed on a heated air drying unit.

Digestion Trials

The reed canarygrass hays were fed to four yearling wethers of about 95 lb. body weight in a total collection digestion trial of a double-reversal design. The preliminary and collection periods were each 7 days.

The early-cut timothy hays were fed to four yearling wethers of about 95 lb. body weight in a total collection digestion trial of a 4 x 4 Latin square design. A fourth diet was added; "urea-supplemented hay" which consisted of the unfertilized hay plus urea so that the nitrogen percentage was nearly equal to that of the urea-sprayed hay. The supplementary urea was dissolved in small amounts of water and carefully sprinkled on the hay at each feeding. The preliminary periods were 10 days and the collection periods were 7 days.

The late-cut timothy hays were fed to three bull calves weighing between 380 and 480 lb. in a total collection digestion trial of a 3 x 3 Latin square design. One was a Holstein and the others were Holstein-Angus crosses. The preliminary and collection periods were each 7 days.

"In Vivo" Bag Technique

All hay samples were evaluated by an *"in vivo"* bag technique, similar to that used by Belasco *et al.* (1958), in which approximately 20 to 25 gm. samples of the chopped, dry forage were placed in 3 x 9 in. "Dacron" cloth bags (100 mesh) and exposed to the digestive action of rumen microorganisms by being submerged in the ventral part of the rumen of a rumen-fistulated steer. After a specified time, the hay samples were recovered from the rumen and the extent of losses determined. An experiment (Merrill, 1959) showed that allowing reed canarygrass hay to remain in the rumen for 48 hours gave dry matter losses of a similar magnitude to those obtained from the conventional digestion trial. On this basis, all hays evaluated by this method were left in the rumen for 48 hours. The same steer was used in all experiments and was fed a total of 20 lb. of medium quality alfalfa hay in equal amounts twice daily.

In Vitro Rumen Fermentation Procedure

The method used was essentially that of Hershberger *et al.* (1959) except that volumes and quantities of materials were approximately one-half of the amounts they used. The procedure is outlined in detail by Merrill (1959). *In vitro* cellulose digestibility was measured by this method.

Analytical Methods

Proximate analyses (A.O.A.C., 1950) were carried out on all samples of feeds and feces from digestion trials. Cellulose analysis of feeds and feces was made by the method of Crampton and Maynard, (1938) with slight modifications (Merrill, 1959).

Rate of Uptake Studies

A greenhouse experiment was conducted in which 0 and 100 lb. of nitrogen per acre was applied to orchardgrass (*Dactylis glomerata*). Samples were taken 3, 6, 19, 24, and 48 hours after application of the foliar spray. The samples were washed in 3 volumes of water, the washings composited and evaporated in the presence of sulfuric acid. Both the washing residue and the dried plant material was submitted to a Kjeldahl total nitrogen analysis.

Yield Studies

Orchardgrass and bromegrass (*Bromus inermis*) plots were available which had been seeded 6 years and had not been fertilized with nitrogen during that time. A randomized block, split plot design with the two grasses as subplots was used. Five treatments were applied as follows: (1) check, (2) 200 lb. NH_4NO_3 applied to the soil in four increments of 50 lb. each, (3) 200 lb. of urea as in (2), (4) 200 lb. urea in increments, applied to the foliage 20 days after (2) or 10 days before cutting, (5) 400 lb. of urea applied as in (4). The forage was harvested four times during the season.

Results

The chemical composition of the forages is shown in table 1. The fertilized forages

TABLE 1 CHEMICAL COMPOSITION OF THE FORAGES

Hays	DM (%)	Composition of dry matter (%)					
		Protein (N x 6.25)	Ether extract	Crude fiber	N-free extract	Ash	Cellulose
Reed canarygrass[a]							
Unfertilized	91.4	13.0	3.5	26.9	47.2	9.4	26.3
Urea sprayed	92.1	16.1	3.4	25.2	46.0	9.3	25.6
Early-cut timothy[b]							
Unfertilized	92.2	11.6	3.0	31.3	48.2	5.9	30.2
Soil fertilized	92.3	15.2	3.0	29.6	46.7	5.5	29.6
Urea sprayed	91.5	13.7	3.0	30.9	46.7	5.7	30.1
Late-cut timothy[a]							
Unfertilized	91.4	5.6	2.0	40.0	48.9	3.5	35.8
Soil fertilized	89.1	8.3	1.9	40.6	45.5	3.7	36.1
Urea sprayed	91.4	8.2	2.1	39.9	45.9	3.9	36.4

[a] Each value is an average of three observations.
[b] Each value is an average of four observations.

were significantly higher in protein than the unfertilized, for reed canarygrass at $P<0.05$ and for timothy at $P<0.01$. With early-cut timothy soil fertilizaton resulted in significantly higher protein than urea spraying ($P<0.01$), but for late-cut timothy they were not different. There were no other important differences in composition.

Table 2 shows the average apparent digestion coefficients and percent TDN of the forages. Within each of the three kinds of hay, the apparent digestibility of the protein of the unfertilized hay was significantly less ($P<0.01$) than that of the other hays. None of the other comparisons between the unfertilized and the treated hays were significantly different ($P<0.05$).

Table 3 shows the average percent loss of nutrients using the *"in vivo"* bag technique. Since the recovered undigested residue from each bag was only 6 to 9 gm., the residues from the replicate bags for each hay were composited for chemical analysis. Therefore, except for the dry matter losses, (not significantly different) all the values in table 3 are "single observations" and are not subject to statistical treatment. In all cases the number of replications were small, but it can be observed for the reed canarygrass hay that all the losses were greater for the sprayed hay, especially the dry matter, protein and cellulose losses. For the early-cut timothy hay, it is apparent that differences in nutrient losses were small and variable, being slightly greater for the unfertilized hay in most comparisons. However, the protein loss was slightly greater for the fertilized hays. For the late-cut timothy, the protein loss for the fertilized hays was twice as large as for the unfertilized hay. The crude fiber, cellulose and dry matter losses were greater for the urea-sprayed hay but the differences are not large.

As stated under experimental procedures,

TABLE 2. AVERAGE APPARENT DIGESTION COEFFICIENTS AND PERCENT TDN OF THE FORAGES

Hay	Crude protein	Ether extract	Crude fiber	N-free extract	TDN	Dry matter	Cellulose
Reed canarygrass[a]							
Unfertilized	65.4	35.6	63.5	67.8	55.2	63.1	67.8
Urea sprayed	71.4	36.3	61.6	67.3	56.0	63.3	66.7
Early-cut timothy[b]							
Unfertilized	65.6	46.6	69.7	69.7	61.0	66.6	71.7
Soil fertilized	72.7	47.4	68.0	70.0	61.8	67.8	72.5
Urea sprayed	71.6	49.2	66.8	69.5	60.6	67.0	71.0
Urea supplemented	72.2	50.2	70.3	68.4	61.7	67.1	72.9
Late-cut timothy[c]							
Unfertilized	37.5	52.1	50.2	52.3	46.3	50.1	54.0
Soil fertilized	53.0	44.5	56.0	52.2	45.0	50.3	55.0
Urea sprayed	51.8	48.1	51.6	51.0	47.1	51.3	57.0

[a] Each value is an average of six observations.
[b] Each value is an average of four observations.
[c] Each value is an average of three observations, except for the soil fertilized hay, where only two observations are included due to a mishap in period 1.

TABLE 3. PERCENT LOSS OF NUTRIENTS FROM FORAGES USING AN *"IN VIVO"* BAG TECHNIQUE

Hay	Crude protein	Ether extract	Crude fiber	N-free extract	Ash	Dry matter	Cellulose
Reed canarygrass[a]							
Unfertilized	75	72	55	65	78	65	59
Urea sprayed	82	78	58	68	79	69	64
Early-cut timothy[b]							
Unfertilized	74	70	61	73	84	70	68
Soil fertilized	78	64	59	69	85	68	65
Urea sprayed	77	60	59	69	81	68	65
Late-cut timothy[b]							
Unfertilized	16	32	29	41	55	35	33
Soil fertilized	38	35	30	37	56	35	33
Urea sprayed	37	37	31	40	66	37	35

[a] Each value obtained from composite sample of three bags of hay, each replicate run in 3 successive weeks.
[b] Each value obtained from composite sample of four bags of hay, duplicate bags of each hay were run in two trials a week apart.

the *"in vivo"* bag technique was "standardized" against dry matter digestion coefficients using reed canarygrass hay. In comparing dry matter digestibilities, table 2 and dry matter losses, table 3, it is interesting to note the similarity of these two values for early-cut timothy, but not for late-cut timothy. The higher digestion coefficient for the poorer quality hay is very likely the result of a slower rate of passage during digestion.

In no case was the *in vitro* cellulose digestibility (table 4) significantly greater ($P<0.05$) for the fertilized hays than for the unfertilized hay.

TABLE 4. PERCENT *IN VITRO* CELLULOSE DIGESTIBILITY OF THE FORAGES

Hay	Unfertilized	Soil fertilized	Urea-sprayed
Reed canarygrass[a]	58	..	56
Early-cut timothy[b]	64	63	63
Late-cut timothy[b]	32	36	34

[a] Each value is an average of eight duplicate observations (two trials).
[b] Each value is an average of four duplicate observations (two trials).

The uptake of urea from foliar applications was linear with time and for the total nitrogen applied only 36% was absorbed by the plant in 48 hours (table 5). While repeated foliar applications of urea substantially increased the nitrogen content of the forage, the foliar applications were inferior in terms of yield of forage to the conventional method of applying solid forms of urea or ammonium nitrate to the soil (table 6). Orchardgrass responded more favorably to both solid and foliar applications of nitrogen fertilizer than bromegrass. The differences between all treatments, including orchardgrass versus bromegrass, were significant ($P<0.01$) except for the differences in combined nitrogen content between the two solid fertilizer treatments and the two urea spray treatments which were non-significant.

TABLE 5. PERCENT OF FOLIARLY APPLIED NITROGEN ABSORBED BY ORCHARDGRASS PLANTS AT GIVEN TIME INTERVALS FOLLOWING APPLICATION

Hours after application[a]	Percent of nitrogen absorbed[b]
3	12
6	13
19	20
24	24
48	36

[a] For each observation, there were three replicates of sprayed plants and one of control plants.
[b] Calculated by subtracting the amount of nitrogen present in check plants from the amount of nitrogen in the plants for each treatment, the difference expressed as a percent of the amount applied.

TABLE 6. INFLUENCE OF RATES, SOURCES AND METHOD OF NITROGEN FERTILIZATION ON THE YIELD AND NITROGEN CONTENT OF ORCHARDGRASS AND BROMEGRASS

	Yield		Combined nitrogen content of both forages
	Orchardgrass	Bromegrass	
Treatment	Tons/acre	Tons/acre	(%) D. M. Basis
Check	.72	.83	2.43
Solid NH_4NO_3 (200 lb. N/acre)	3.16	2.70	2.85
Solid urea (200 lb. N/acre)	2.91	2.50	2.98
Urea spray (200 lb. N/acre)	2.11	1.98	3.47
Urea spray (400 lb. N/acre)	3.60	2.89	3.73

Discussion

As pointed out in the review by Ward (1959), applications of nitrogen fertilizer to hay and pasture crops have resulted in inincreased nitrogen content in the forage in numerous cases. In the experiments reported here, either soil or foliar applications of urea (ranging from 90 to 267 lb. of urea per acre) increased the nitrogen content of the hays table 1).

For each forage, the apparent digestibility of the protein in the unfertilized hay was significantly lower ($P<0.01$) than that for any of the urea-fertilized (either soil or foliar applications) or urea-supplemented hays. However, the comparisons in table 7 show that

TABLE 7. RELATIONSHIP OF APPARENT AND TRUE DIGESTIBILITY OF PROTEIN TO PROTEIN CONTENT OF FORAGES

Hay	Crude protein (%) [a]	Digestibility (%)	
		Apparent	True [b]
Reed canarygrass			
Unfertilized	13.0	65.4	89
Urea sprayed	16.1	71.4	91
Early-cut timothy			
Unfertilized	11.6	65.6	93
Soil fertilized	15.2	72.7	93
Urea sprayed	13.7	71.6	95
Urea supplemented	13.9	72.2	95
Late-cut timothy			
Unfertilized	5.6	37.5	93
Soil fertilized	8.3	53.0	91
Urea sprayed	8.2	51.8	90

[a] Dry matter basis.
[b] Calculated true digestibility assuming metabolic fecal nitrogen of 0.5 gm. nitrogen per 100 gm. dry matter intake (Maynard and Loosli, 1956).

there is very little variation among the calculated true digestibilities of protein. It has been shown many times that the apparent digestibility of protein can be expected to increase with an increased protein content of the diet (Mitchell, 1926; Gallup and Briggs, 1948); Glover *et al.*, 1957; French *et al.*, 1957; Hutchinson, 1958; Holter and Reid, 1959). Among others, Mitchell (1926) has discussed this relationship and has shown that it results from the factors governing the excretion of metabolic nitrogen in the feces. There is little variation in the true digestibility of protein of natural feedstuffs either for all roughage or mixed rations, regardless of protein content, (Mitchell, 1926; Titus, 1927; Glover *et al.*, 1957; French *et al.*, 1957; Reid *et al.*, 1959; Holter and Reid, 1959). Therefore in experiments of this kind it is important not to interpret a difference in apparent digestibility of protein as due to a change in the quality or availability of this nutrient.

It is true that apparent digestibility has direct application to feeding practice. As the apparent digestibility increases, the animal may benefit from the absorption of the added amount of protein. It should be appreciated that this is due to a greater nitrogen intake per unit of dry matter, not because each unit is really more digestible. Several formulas have been proposed by which apparent digestibility of protein can be predicted from the protein content of the diet (Mitchell, 1942; Glover *et al.*, 1957; Holter and Reid, 1959).

The results using the *"in vivo"* bag technique showed a greater loss of protein from the fertilized hays with the higher protein content than from the unfertilized hay. Obviously, the factors governing the excretion of metabolic fecal nitrogen, which explain the relationship between protein content and its apparent digestibility, do not apply here. Using the *"in vivo"* bag technique, there was clearly a greater percentage loss of protein from the fertilized hays. This greater loss of protein from the fertilized hays can not be attributed to unabsorbed urea on the leaf surface or to a difference in soluble loss due to leaching. Bags of these hays (as used in the *"in vivo"* bag technique) were submerged for 48 hours in a water bath and the soluble losses were similar for all hays whether unfertilized or fertilized by soil or foliar applications of urea. The data from these experiments are insufficient to explain the greater percentage loss of protein from the fertilized hays. It may be that the *"in vivo"* bag technique is sensitive to differences in the crude protein fraction that one would not expect to detect from digestion trials unless true digestibility of the protein or nitrogen balance were measured. On the other hand, the *"in vivo"* bag technique of determining the nutritive value of protein has the same limitation as digestion trials; both procedures measure the loss or digestibility of the protein, but they do not measure its retention or utilization by the animal. Nitrogen balance data were intended as a part of the "digestion trial" studies, but difficulties were encountered in maintaining feed intakes at a level high enough to prevent weight loss in many of the animals. Perhaps the important point to be considered here is that the loss of pro-

tein, using the *"in vivo"* bag technique, was the same for both fertilized hays, indicating no advantage for the urea-sprayed hay.

Markley *et al.* (1959) reported the effects of nitrogen fertilization or urea supplementation on the digestibility of orchardgrass hay. The urea-supplemented hay ration consisted of the unfertilized hay sprayed with a solution of urea before feeding and allowed to dry. The amount of urea added to the unfertilized hay gave the urea-supplemented hay a "protein equivalent" equal to the protein content of the fertilized hay which had been produced with 200 lb. nitrogen per acre. They reported that for the urea-supplemented ration the apparent digestibility of the protein and the percent TDN were significantly greater than for either the unfertilized or nitrogen-fertilized hay.

The additional amount of nitrogen absorbed from such a diet is probably of little value. Mills *et al.* (1942) were among the first to show little, if any, utilization of urea when fed with hay (timothy) alone. In the presence of starch or any other moderately available carbohydrate, a suitable substrate was provided for efficient urea utilization. It has been shown numerous times that urea is rapidly hydrolyzed to ammonia, which is quickly absorbed and excreted unless conditions are favorable for utilization by microorganisms, (Reid, 1953; Loosli, 1958). The fact that Markley *et al.* (1959) showed no significant difference for nitrogen balance between the unfertilized and urea-supplemented hay indicates that adding urea to the ration of hay only, was of very little benefit, if any, in increasing nitrogen utilization.

Markley *et al.* (1959) also reported that the addition of urea to the unfertilized hay significantly increased the TDN of that ration above the unfertilized hay, but they reported no difference between the two hays in digestible energy. These two measures of energy value are highly correlated (Swift, 1957; Hardison, 1959; Reid *et al.*, 1959). This discrepancy is due to their interpretation or use of the chemical composition of the urea-supplemented hay. This is reflected in their data as the components of chemical composition of their urea-supplemented hay total 106.1%. In their table of chemical composition, total nitrogen is expressed as protein equivalent, but it must be remembered that urea provides only nitrogen, it does not furnish energy value to the animal as does protein. Basing the TDN calculation on this incorrect chemical composition gives a TDN value which is too high. When adjusted for this error, the TDN value for the urea-supplemented hay does not appear to be significantly different from the TDN value of the unfertilized hay.

With the size and type of experiments carried out here, no differences other than higher apparent digestibility of protein, could be detected in nutritive value among hays receiving fertilization or supplementation with urea. These results do not agree with those of Belasco *et al.* (1958) who reported that spraying grasses with solutions of urea improved their nutritive value by significantly increasing the digestibility of protein, dry matter and cellulose. For example, they reported a 34% increase in the *in vitro* cellulose digestibility for hay that had been sprayed with only 10 lb. of urea per acre. Perhaps these divergent results are due to differences in types of forages, experimental methods or conditions of soil fertility on which the grasses were grown.

The rate of nitrogen uptake when applied foliarly is not as rapid as one might desire. During the haying season in New York State, a rain-free interval of more than 48 hours is seldom even partially predictable. Hence, any nitrogen not absorbed during that period may be washed off and lost to the farmer as current value because it is too late for it to be taken up by the plant from the soil.

The foliar application of nitrogen did increase the nitrogen content of the leaves more than did the conventional soil applications, but this is of doubtful practical value since even the untreated forage contained sufficient protein to meet the needs of grazing animals.

Summary

The effects of foliar application of urea on the yield, chemical composition, nutritive value and rate of uptake of urea by some grass hays were studied. The forages used for nutritional evaluation were second growth reed canarygrass and early- and late-cut timothy while those used for yield and rate of uptake studies were orchardgrass and bromegrass. Also included in the studies of nutritional value were timothy hays which had been fertilized by soil application of urea and early-cut timothy hay which was supplemented with urea at the time of feeding. The nutritive value of the hays was measured, (1) primarily by digestion trials with sheep and

calves, (2) by an *"in vivo"* bag technique, and (3) by an *in vitro* rumen fermentation procedure.

In all cases, soil and foliar applications of urea increased the crude protein content of the hay and consequently increased the apparent digestibility of the protein but calculated true digestibility was similar for all forages. Yields of forages were increased most by soil applications of nitrogen fertilizer made a month in advance of cutting. Foliar applications made 10 days prior to cutting had much less effect on yield, but did result in a greater increase in the nitrogen content of the forage.

When all the data were considered, there was no indication of any significant difference in the digestibility of any nutrient, except apparent digestibility of protein, among hays which were, (1) unfertilized or not supplemented with urea, (2) fertilized by foliar application of urea, (3) fertilized by soil application of urea, or (4) supplemented with urea at the time of feeding.

Literature Cited

A.O.A.C. 1950. Official methods of analysis (7th ed.). Association of Official Agricultural Chemists. Washington, D. C.

Barth, K. M. 1958. Total digestible nutrients expressed in terms of digestible energy. M.S. Thesis. Rutgers, The State University, N. J.

Belasco, I. J., M. F. Gribbins and D. W. Kolterman. 1958. The response of rumen microorganisms to pasture grasses and prickly pear cactus following foliar applications of urea. J. Animal Sci. 17:209.

Colovos, N. F., H. A. Keener, N. K. Peterson, P. T. Blood and H. A. Davis. 1958. Effect of nitrogen fertilization and stage of maturity on the nutritive value of bromegrass hay. J. Dairy Sci. 41:1835.

Crampton, E. W. and L. A. Maynard. 1938. The relation of cellulose and lignin content to the nutritive value of animal feeds. J. Nutr. 15:383.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics 11:1.

French, M. H., J. Glover and D. W. Duthie. 1957. The apparent digestibility of crude protein by the ruminant. II. The general equation and some of its implications. J. Agr. Sci. 48:379.

Gallup, W. D. and H. M. Briggs. 1948. The apparent digestibility of prairie hay of variable protein content, with some observations of fecal nitrogen excretion by steers in relation to their dry matter intake. J. Animal Sci. 7:110.

Glover, J., D. W. Duthie and M. H. French. 1957. The apparent digestibility of crude protein by the ruminant. I. A synthesis of the results of digestibility trials with herbage and mixed feeds. J. Agr. Sci. 48:373.

Hardison, W. A. 1959. Evaluating the nutritive quality of forage on the basis of energy. A review. J. Dairy Sci. 42:489.

Hershberger, T. V., T. A. Long, E. W. Hartsook and R. W. Swift. 1959. Use of the artificial rumen technique to estimate the nutritive value of forages. J. Animal Sci. 18:770.

Holter, J. A. and J. T. Reid. 1959. Relationship between the concentrations of crude protein and apparently digestible protein in forages. J. Animal Sci. 18:1339.

Hutchinson, K. J. 1958. Factors governing faecal nitrogen wastage in sheep. Australian J. Agr. Res. 9:508.

Loosli, J. K. 1958. Chemical sources of nitrogen as supplements to protein feeds: in Processed Plant Protein Foodstuffs. (A. M. Altschull, ed.). Academic Press, Inc., N. Y.

Markley, R. A., J. L. Cason and B. R. Baumgardt. 1959. Effect of nitrogen fertilization or urea supplementation upon the digestibility of grass hays. J. Dairy Sci. 42:144.

Maynard, L. A. and J. K. Loosli. 1956. Animal Nutrition, 4th ed. McGraw-Hill, N. Y.

Merrill, W. G. 1959. Effects of foliar application of urea on the nutritive value of some grass hays. Ph.D. Thesis. Cornell University, N. Y.

Mills, R. C., A. N. Booth, G. Bohstedt and E. B. Hart. 1942. The utilization of urea by ruminants as influenced by the presence of starch in the ration. J. Dairy Sci. 25:925.

Mitchell, H. H. 1926. The determination of the protein requirements of animals and of the protein values of farm feeds and rations. Natl. Res. Council Bul. No. 55.

Mitchell, H. H. 1942. The evaluation of feeds on the basis of digestible and metabolizable nutrients. J. Animal Sci. 1:159.

Mitchell, R. L. 1958. Nitrogen fertilization of forage crops: Effect on feeding value and foliar application of urea. M.S. Thesis. Cornell University, N. Y.

Poulton, B. R. 1958. The effect of nitrogen fertilization on the nutritive value of forage. Proc. Eastern States Agronomy Conf., Cambridge, Mass.

Poulton, B. R., G. J. MacDonald and G. W. Vander Noot. 1957. The effect of nitrogen fertilization on the nutritive value of orchardgrass hay. J. Animal Sci. 16:462.

Reid, J. T. 1953. Urea as a protein replacement for ruminants: A review. J. Dairy Sci. 36:955.

Reid, J. T., W. K. Kennedy, K. L. Turk, S. T. Slack, G. W. Trimberger and R. P. Murphy. 1959. Effect of growth stage, chemical composition, and physical properties upon the nutritive value of forages. J. Dairy Sci. 42:567.

Swift, R. W. 1957. The nutritive evaluation of forages. Northeast Regional Publication, Bull. 615. Penn. State Univ. Agr. Exp. Sta., University Park, Penn.

Titus, H. W. 1927. The nitrogen metabolism of steers on rations containing alfalfa as the sole source of nitrogen. J. Agr. Res. 34:49.

Ward, G. M. 1959. Effect of soil fertility upon the yield and nutritive value of forages. A review. J. Dairy Sci. 42:277.

SOME EFFECTS ON BEEF CARCASSES FROM FEEDING STILBESTROL

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MANY feeding trials have been reported in which the value of adding stilbestrol to various rations has been studied under conditions of *ad libitum* feed intakes. Few data exist on the effect of adding stilbestrol to a ration when both control and stilbestrol rations are fed in equal amounts. Stouffer *et al.* (1956) reported carcass studies of steers fed equal amounts of concentrates, with and without stilbestrol. No differences were reported for rib eye area, physical composition or specific gravity of the wholesale rib. A higher percent of moisture was found in the *longissimus dorsi* muscle of stilbestrol-fed cattle. Ogilvie *et al.* (1960) reported the effects of orally administered stilbestrol on feed lot performance and carcass characteristics of steers at various stages in the fattening period. Stilbestrol caused a more pronounced increase in carcass protein and moisture and a greater decrease in carcass fat at 56 days than at 168 days. Carcass grade and percent bone were not affected.

The experiment reported here was conducted to determine the effect on carcass composition of steer calves fattened on a standard ration with and without stilbestrol and when feed consumption was kept the same for both groups.

Experimental Procedure

Eighteen steer calves, averaging 450 lb., were paired so that the members of a pair were as much alike as possible. Each animal was fed a basal fattening ration consisting of ground corn, soybean oil meal, grass silage and mixed hay. One member of each pair received orally 10 mg. of stilbestrol per day. The amount of feed consumed by both groups of steers was established by the group, either treated or untreated, which consumed the least feed. Three pairs of steers were removed during the final month of the experiment and slaughtered at the University meats laboratory. The remaining six pairs were slaughtered at Buffalo, New York. The average length of the trial was 193 days.

Detailed slaughter and carcass data were obtained on all cattle. The 9–11 rib sections were removed from the wholesale cuts according to the method proposed by Hopper (1944). The lean, fat and bone were physically separated and sampled for chemical analysis. Standard A.O.A.C. (1945) specifications were followed for nitrogen, ether extract and ash analyses. A freeze-dry unit was employed for drying and determining the moisture content of the samples. The cross-sectional area of each rib-eye muscle was determined from a tracing at the 12th rib by use of a compensating polar planimeter. Average subcutaneous fat thickness was determined from the 12th rib tracings. The 12th rib cuts were photographed for a permanent record of marbling and printed to scale on non-shrinkable paper. By photographing the cuts under water, photographical errors due to light reflection were minimized.

Also, the composition of the intact, empty bodies of the steers was estimated by two methods. One was based on the analysis of the 9–11 rib data as suggested by Hopper (1944). The other was based on body water as measured by use of antipyrine (Reid *et al.*, 1955).

Results and Discussion

Feed-lot performance data are summarized in table 1. The steers fed 10 mg. of stilbestrol per head daily in the soybean oil meal outgained the control steers an average of 0.16 lb. per head daily. This difference was not statistically significant. While this response was not as great as some reported for stilbestrol-fed steers, it was made on the same average daily feed intake as the control lot. Numerous experiments reporting the effects of feeding stilbestrol indicate an appetite stimulation. It was observed in this experiment that the stilbestrol-fed steers showed keener appetites and they consumed their feed more rapidly than the control steers.

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TABLE 1. SUMMARY OF FEED LOT PERFORMANCE DATA FOR CONTROL AND STILBESTROL-FED STEERS

	Control	Stilbestrol-fed[a]
No. of steers	9	9
Av. no. days on trial	193	193
Av. initial wt., lb.	450	450
Av. final wt., lb.	902	933
Av. total gain, lb.	452	483
Av. daily gain, lb.	2.34	2.50
Av. daily feed consumption		
Ground corn, lb.	10.9	10.9
Soybean oil meal, lb.	2.0	2.0
Grass silage, lb.	7.1	7.1
Mixed hay, lb.	2.3	2.3
Feed per 100 lb. gain		
Ground corn, lb.	465	435
Soybean oil meal, lb.	85	80
Grass silage, lb.	304	285
Mixed hay, lb.	97	91

[a] 10 mg. stilbestrol per head daily.

As shown in table 2, average carcass grades and dressing percent were essentially equal for the two lots of cattle. The lumbo-sacral angles were more acute in the carcasses of treated steers. This difference approached significance. The depth of chest measurement was significantly greater ($P<0.05$) for stilbestrol-fed steers. Other carcass measurements were not statistically different, but the general trend indicated slightly thicker dimensions for fore and rear quarters of the treated cattle.

Visual inspection of photographs of the 12th rib pairs indicated definite differences in marbling. Visual comparisons of each pair by 10 members of the Animal Husbandry Department showed that ribs cut from the control steers were selected as having more marbling four times, ribs cut from treated steers were selected one time, and the remaining four pairs were chosen inconsistently. Clegg and Cole (1954) reported less marbling, darker color, and coarser-textured lean in carcasses from animals receiving stilbestrol.

Since the 12th rib steaks were immersed in water when photographed, percent ether extract is expressed on a dry basis. The ether extract of the dry rib eyes was significantly higher ($P<0.05$) for the controls. No treatment differences were found in the area of the rib-eye muscles. The average area of all rib eyes was approximately 10 square inches. Average subcutaneous fat thickness over the rib-eye was similar for treated and control cattle.

Physical separation of the 9–11 rib sections into lean, fat and bone revealed no real differences due to treatment (table 3). However, the presence of less total fat and a corresponding greater percent of total lean tissue was indicated for the ribs from stilbestrol-fed steers.

TABLE 2. CARCASS DATA FOR CONTROL AND STILBESTROL-FED STEERS

	Control	Stilbestrol-fed
U.S.D.A. Grade		
Choice +	1	1
Choice av.	5	3
Choice —	1	2
Good +	2	2
Good av.	0	1
Coded av.[a]	2.5	2.9
Av. hot carcass wt., lb.	529	549
Av. dressing percent, 1½% shrink	59.7	59.9
Av. lumbosacral angle, degrees	131	129
Av. length of body, mm.	1148	1155
Av. circumference of round, mm.	905	918
Av. thickness of round, mm.	481	486
Av. thickness of shoulder, mm.	439	444
Av. depth of chest, mm.	377	382*
Av. length of loin, mm.	605	601
Av. rib-eye area, sq. in.	10.01	9.97
Av. fat thickness over rib-eye, in.	0.77	0.82
Av. rib-eye-ether extract, dry %	21.79	17.93*

[a] Choice +(1), Choice av. (2), Choice —(3), etc.
* Significant at the 5% level.

TABLE 3. PHYSICAL AND CHEMICAL COMPOSITIONS OF 9–11 RIB OF CONTROL AND STILBESTROL-FED STEERS

	Control	Stilbestrol-fed
	%	%
Physical composition of 9–11 rib		
Total lean	50.76	52.52
Total fat	34.27	32.77
Total bone	14.02	13.78
Chemical composition of 9–11 rib		
Total lean		
Water	67.53	69.21**
Ether extract	12.43	10.29**
Protein	18.77	18.85
Ash	1.01	1.01
Total fat		
Water	10.83	11.44
Ether extract	85.70	84.67
Protein	4.08	4.13
Total bone		
Water	33.69	32.59
Ether extract	16.17	14.39
Protein	22.11	23.54**
Ash	26.68	29.12
Reconstituted 9–11 rib (wet)		
Water	42.71	44.54
Ether extract	37.94	35.20
Protein	14.02	14.49
Ash	4.25	4.53

** Significant at the 1% level.

Chemical assay of the 9–11 rib sections revealed a higher percent of water ($P<0.01$) and a lower percent of ether extract ($P<0.01$) in lean tissue from the ribs of treated steers (table 3). These findings further substantiate the data from analysis of the rib-eye muscle which indicated a higher degree of marbling in lean from the control cattle. The crude protein content of bony tissue in the ribs from stilbestrol-fed cattle was significantly higher ($P<0.01$). Also, the bone from the treated steers contained a lower percent of ether extract ($P<0.10$) and a higher percent of ash ($P<0.10$).

The percent chemical composition of the reconstituted 9–11 rib sections is given in table 3. The average recovery of the wet reconstituted ribs was 98.84%. No statistical differences in percent of protein or ash were detected in the wet 9–11 rib sections. However, the greater percent of water and the lower percent of ether extract in the ribs from the treated steers were approaching significance ($P<0.10$).

There was more water and less ether extract in the 9–11 rib sections of stilbestrol-fed steers, which suggest that treated steers did not have as much finish as control steers. The data also show slightly more protein in the 9–11 rib sections of the treated steers, although the protein content of bone was the main contributing source of this difference. Likewise, the data suggest a higher ash content of the 9–11 rib sections from steers which were fed stilbestrol primarily due to the higher ash content of bone from treated steers. Increased density of bone due to estrogenic stimulation has been attributed to an increase in concentration of ash in the whole bone (Day and Follis, 1941).

Table 4 presents the average estimated composition of the whole empty bodies of all the steers in this study based on rib analysis and of four pairs of steers based on the antipyrine method. There was significantly greater ($P<0.01$) protein and significantly lower ($P<0.05$) ether extract in the empty bodies of treated steers. There was also significantly more ($P<0.10$) water and ash in the treated steers. These data indicate differences in body composition between steers fed similar rations with and without stilbestrol. Changes in the bony tissue may have an important role in the over-all change brought about by stilbestrol administration, and these changes should be investigated further.

TABLE 4. ESTIMATED COMPOSITION OF WHOLE EMPTY BODIES OF CONTROL AND STILBESTROL-FED STEERS

	Water		Ether extract		Protein		Ash	
	Rib[a]	AP[b]	Rib	AP	Rib	AP	Rib	AP
	%	%	%	%	%	%	%	%
Stilbestrol[c]	53.86	54.10	25.68	23.58	15.96	17.98	3.97	4.35
Control	51.03	49.07	29.58	30.32	15.13	16.60	3.76	4.02
Stilbestrol[d]	52.64	.....	27.36*	.....	15.60**	.....	3.88	....
Control	51.33	.....	29.18	.....	15.21	.....	3.79	....

[a] Rib=Predicted from chemical composition of 9–11 rib.
[b] AP=Predicted from body water determination using antipyrine.
[c] Averages for 4 pairs of steers.
[d] Averages for 9 pairs of steers.
* Significant at the 5% level.
** Significant at the 1% level.

Summary

Eighteen steers were paired and randomly assigned to either a control ration or a ration containing 10 mg. of stilbestrol per steer daily. The rations were fed in equal quantities to both lots as determined by the group which consumed the least feed. Average length of the feeding period was 193 days.

Steers receiving stilbestrol gained faster and were more efficient in feed conversion. Carcass grades and yields were essentially equal. Other than a significant increase in chest depth, various carcass measurements were not statistically different. Visual comparison of photographs of the 12th rib cut and percent ether extract of the rib-eye muscles showed less marbling in rib eyes from treated cattle. No difference was found in the area of the rib eyes or fat thickness covering the rib eye. The 9–11 rib sections from stilbestrol-fed cattle contained less extract and more water, protein and ash. The higher amount of protein and ash in the bones of treated steers was a major contributing factor in the protein and ash of the reconstituted 9–11 ribs.

Estimations of body composition based on either 9–11 rib analysis data or antipyrine data were in close agreement.

Literature Cited

A.O.A.C. 1945. Official Methods of Analysis. Association of Official Agricultural Chemists, Washington, D. C.

Clegg, M. T. and H. H. Cole. 1954. The action of stilbestrol on the growth response in ruminants. J. Animal Sci. 13:108.

Day, H. G. and R. H. Follis, Jr. 1941. Skeletal changes in rats receiving estradiol benzoate as indicated by histological studies and determinations of bone ash, serum calcium and phosphatase. Endocr. 28:83.

Hopper, T. H. 1944. Methods of estimating the physical and chemical composition of cattle. J. Agr. Res. 68:239.

Ogilvie, M. L., E. C. Faltin, E. R. Hauser, R. W. Bray and W. G. Hoekstra. 1960. Effects of stilbestrol in altering carcass composition and feed lot performance of beef steers. J. Animal Sci. 19:991.

Reid, J. T., G. H. Wellington and H. O. Dunn. 1955. Some relationships among the major chemical components of the bovine body and their application to nutritional investigations. J. Dairy Sci. 38:1344.

Stouffer, J. R., S. Bull, B. C. Breidenstein, A. L. Neumann and W. W. Albert. 1956. Effect of stilbestrol on beef carcass quality as measured by physical and chemical determinations. J. Animal Sci. 15:1267 (Abstr.).

FREEZING—A TECHNIQUE FOR FORAGE INVESTIGATIONS [1, 2]

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FREEZING, a process used to preserve a wide variety of products (Tressler and Evers, 1957) with little loss of nutrients (Joslyn and Diehl, 1952) has been successfully employed to preserve forages for digestibility trials by Raymond *et al.* (1949, 1953) and in this laboratory. Such a process eliminates the necessity of daily cuttings and the continuous changes in plant maturity associated with them. Also, the objections commonly noted with the conventional storage processes (Mather *et al.*, 1956; Newlander *et al.*, 1940; Miller *et al.*, 1954; Watson and Ferguson, 1932; McDougall and DeLong, 1942; Ferguson and Terry, 1955) are also avoided. However, no data have been reported on the comparative intake of fresh and frozen forages. Since voluntary consumption is an important criterion of forage quality (Crampton *et al.*, 1960; Spahr *et al.*, 1961) this investigation was undertaken primarily to obtain information on this point with sheep. As chopping facilitates handling and sampling, and conserves freezer space, a comparison of chopped vs. long forage was included. Comparative rates of digestion of fresh vs. frozen forages were also studied.

Experimental Procedure

Four trials were conducted. Trials 1, 2 and 3 involved feeding a variety of fresh and frozen green forages to sheep in both the chopped and long form. Trial 4 dealt with rate of digestion of fresh and frozen forage in fistulated steers.

A description of the forages fed in Trials 1, 2 and 3, including species, stages of maturity and chemical compositions, is given in table 1. Forages were cut each afternoon with a sickle-bar mower and immediately transported to the laboratory. One-half of each cutting was chopped to about 1 in. in length in a cylinder-type chopper before the forages were sampled for chemical analyses and weighed into polyethylene bags. These bags were then assigned to frozen and fresh lots. Dry ice was added to each bag in the lot to be frozen at the rate of approximately 1 lb. for 10 lb. of forage, after which the bags were sealed and placed in a freezer [3] set at –10° F. The bags in the fresh lot were divided into morning and evening feedings. Those for the evening feedings received no further treatment but those for the following morning were gassed with CO_2 by adding a small amount of powdered dry ice before the bags were sealed and left in a cool place. After 1 day the frozen forage was taken from the freezer and placed before the animals in the frozen state, care being taken to break up any large lumps of frozen material.

Thirty-two yearling ewes of an average weight of 104 lb. were employed in the three feeding trials. The trials ran consecutively, the same group of animals being used in each trial. The experiment was originally designed to include four species of forages with the consecutive trials representing stages of maturity. Because drought conditions reduced the amount of forage available, the experiment was modified by eliminating some treatments, reducing the length of Trial 3 and by including two additional forages. Animals were assigned to the treatments completely at random, with two animals on each species within the groups Fresh-long, Frozen-long, Fresh-chopped, Frozen-chopped as indicated in table 2.

The three trials were 10, 2 and 5 days in length respectively, the length of the trial being determined by the quantity of pure species of forage available. Trial 2 served as a changeover period from Trial 1 to Trial 3.

Animals assigned to the frozen forage received a uniform mixture of grass-legume forage in the frozen state for a pre-treatment

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[2] The authors wish to thank W. Emond for technical assistance, Genetics and Plant Breeding Research Institute for providing some of the forages, and Analytical Chemistry Research Service for conducting the proximate analyses.

[3] Refrigeration rooms, 1000 cu. ft., made with prefabricated plywood sheeted sections supplied by C. P. Fabien Limited, Montreal, Quebec, or Ontario Refrigeration Enterprises Limited, Highland Creek, Ontario, each equipped with a 3 h.p. compressor, were used in these studies.

TABLE 1. SPECIES, STAGES OF MATURITY AND CHEMICAL COMPOSITION OF FORAGES FED

Species	Varieties	Trial	Stages of maturity	Dry matter (as fed)	Chemical composition of forages (dry matter basis) Crude protein	Crude fibre	Ether extract	Nitrogen free extract	Ash
				%	%	%	%	%	%
Red clover *Trifolium pratense* (L)	Ottawa	1	¼ to full bloom	23.5	15.6	22.6	1.4	52.1	8.3
		2	Full bloom	21.7	14.1	22.5	1.8	53.3	8.3
		3	Full to post-bloom	23.4	15.2	23.4	1.4	51.5	8.6
Alfalfa *Medicago sativa* (L)	Vernal	1	¼–½ bloom	25.2	16.5	34.4	1.5	39.0	8.6
		2	Pre-bloom (2nd growth)	23.1	20.0	24.6	1.7	42.5	11.2
		3	Pre-bloom (2nd growth)	27.2	18.8	26.9	1.6	43.7	9.1
Brome *Bromus inermis* (Leyss)	Lincoln	1	Full bloom	29.0	12.8	30.0	2.4	48.0	6.8
Green oats *Avena sativa* (L)	Rodney	2	Headed	19.7	10.6	25.2	2.5	52.6	9.1
		3	Pre-headed	17.9	15.6	24.9	2.6	46.4	10.6
Orchard grass *Dactylis glomerata* (L)	Hercules	1	Full bloom	28.0	11.7	30.2	2.6	46.8	8.7
		2	Immature (2nd growth)	24.3	16.8	28.1	2.5	42.4	10.1
		3	Immature (2nd growth)	26.7	16.7	29.3	2.9	41.0	10.1
Birdsfoot trefoil *Lotus corniculatus* (L)	Viking	2	Full bloom	24.2	14.2	30.1	1.3	46.7	7.7
		3	Post-bloom with seed pods	25.9	13.6	29.5	2.2	48.2	6.5

period of 7 days prior to the beginning of Trial 1. Those assigned to the non-frozen treatment received the same forage in the fresh state. All the ewes were housed in an open shed which provided access to dry paddocks and were fed in individual feeding crates. They were let into crates at 7:00 a.m. and 3:00 p.m., allowed to feed for 2 hours and then shut out again. Sufficient feed was offered to ensure a weigh-back after each feeding. Weigh-backs were stored in the freezer and composited on a period basis.

The data were analyzed by analysis of variance. In Trials 2 and 3 the supply of orchard grass and birdsfoot trefoil was inadequate to allow a chopped vs. long comparison. Therefore, these two trials were divided into two parts: Part A included the chopped and long data on red clover, alfalfa and green oats, whereas Part B included only the

TABLE 2. EFFECT OF FREEZING AND OF CHOPPING ON CONSUMPTION OF GREEN FORAGES BY SHEEP

Species	Trial no.	Average dry matter consumption: Long Fresh	Long Frozen	Chopped Fresh	Chopped Frozen	Mean
		(gm/day)	(gm/day)	(gm/day)	(gm/day)	(gm/day)
Red	1	1404	1356	1306	1184	1312
Clover	2	1552	1536	1592	1676	1589
	3	1685	1628	1680	1766	1690
Alfalfa	1	1232	1016	1041	1086	1094
	2	953	1306	1329	1290	1220
	3	1599	1602	1687	1442	1582
Brome	1	1232	1091	1023	964	1078
Green oats	2	1243	1204	1168	1075	1172
	3	1392	1274	1216	1252	1284
Orchard	1	1174	1054	1064	1064	1089
grass	2	....	....	892	1011	952
	3	....	....	1118	1134	1126
Birdsfoot	2	....	....	1168	1266	1217
trefoil	3	....	....	1572	1590	1581
	Means	1347	1307	1311[a]	1280[a]	1311[a]
				1275	1271	1273

[a] Mean does not include orchard grass and birdsfoot trefoil in Trials 2 and 3.

chopped data on all species and each part was analyzed individually.

In Trial 4, the fresh and the frozen forages were fed each for a separate period of 7 days' duration. Only two fistulated steers and one forage, immature alfalfa, were used in this trial. Sufficient forage was cut each morning during the first period with a flail-type forage harvester for 2 days' feeding. One portion of the forage was fed to both steers the day that it was cut whereas the second portion was frozen in plastic bags and kept for the second period.

Five samples of the same forage as fed were sealed in silk bags and placed into the rumen through the fistula of each steer each day for the last 4 days of each period about 30 min. after commencement of feeding, then one bag was removed at zero, 3, 6, 12 and 24 hours. (The 0 hr. bag was in the rumen not longer than 1 min.). These samples were prepared using the technique described by McAnnally (1942) with slight modifications. The bags were made from strips of silk 5 in. wide and 18 in. long, sewn up the sides and each identified with a metal tag. The bags were tared, then 20-gm. samples of the forage, wet weight, were ground for 30 sec. in a Waring blender and washed into the bags. They were held in place in the rumen using the technique described by Erwin and Elliston (1959). When removed from the rumen the bags were frozen immediately to stop microbial action and for storage. Later they were thawed, dialyzed with running water and dried at 100° C. By weighing the bag with its contents the dry matter remaining in the bag could be calculated.

During the second period the frozen forage was fed in the same sequence as the fresh forage had been fed. The samples of the forage, which had been frozen in the silk bags, were incubated in a similar manner.

Results and Discussion

The procedures used for freezing forage in this study were quite satisfactory. The addition of dry ice in conjunction with polyethylene bags is an important step to suppress aerobic respiration during the freezing period and to eliminate the necessity for a quick-freeze unit. Without the dry ice the load capacity of the freezers is greatly reduced and up to 24 hours may elapse before the centers of the bags are frozen. Once freezing has occurred the polyethylene bags prevent moisture loss, thus eliminating many time-consuming dry matter determinations.

Caution must always be exercised when entering the freezer containing high concentrations of carbon dioxide gas. The freezer must be allowed to air out before personnel work in such areas.

TABLE 3. ANALYSIS OF VARIANCE OF FEED CONSUMPTION DATA IN TRIALS 1, 2, AND 3

Source of variation	Trial 1		Trial 2A		Trial 2B		Trial 3A		Trial 3B	
	d.f.	m.s.	d.f.	m.s.	d.f.	m.s.	d.f.	m.s.	d.f.	m.s.
F (freezing)	1	54,286	1	10,711	1	5,746	1	14,504	1	1,567
C (chopping)	1	85,492	1	18,760	..	....	1	3,128	..	....
S (species)	3	102,386 **	2	415,222	4	257,839 **	2	354,868 *	4	256,715 *
F x C	1	18,817	1	20,242	..	....	1	1,928	..	....
F x S	3	538	2	25,358	4	8,807	2	16,918	4	16,867
C x S	3	6,513	2	41,344	..	....	2	14,102	..	....
F x C x S	3	9,546	2	32,015	..	....	2	18,408	..	....
Error	16	32,534	12	8,101	10	13,216	12	12,642	10	15,785

* $P<0.05$.
** $P<0.01$.

The use of dry ice for gassing forage to be held in polyethylene bags without freezing for a few hours prior to feeding also appears to be a useful technique for inhibiting oxidative degeneration. Chopped forages in quantities of 10 lb. or more which were placed into polyethylene bags, gassed with carbon dioxide by adding powdered dry ice and sealed with wire ties, did not heat or discolor when held at room temperature for 12 to 15 hours.

The method of chopping is also of importance. If the forage is cut to about 1 in. in length with a cylinder-type chopper, it can be frozen without excessive lumping. However, if the forage is chopped with a flail-type chopper, it tends to freeze together, particularly if the forage is immature, and this creates difficulties for feeding in the frozen state.

The sheep appeared to consume the frozen forage directly from the freezer as readily as in the fresh state. The results of Trials 1, 2 and 3 are shown in table 2 as mean consumptions of dry matter and the analysis of variance of the data is given in table 3.

Neither freezing nor chopping had any appreciable effect on the consumption of forages over the wide range of species tested. Consumption varied widely with species but much of the difference was due to stage of maturity.

The high intakes of red clover at an advanced stage of maturity are of interest. This Ottawa variety also appears to be unusual in that protein and fibre remained virtually constant (table 1) over a period when rapid changes are usually experienced. Relatively high intakes of the mature birdsfoot trefoil were also noted. If later studies confirm these observations these forages should be well adapted to situations where late cutting or pasturing is unavoidable.

The relatively low consumption of alfalfa as compared to red clover at the same growth stage may have been due to the occasional bloat noted in some animals on the alfalfa treatments. Some animals bloated after consuming only one-half of their ration. The incidence of bloat was as high among the sheep fed the frozen alfalfa as among those eating the fresh. This observation may be of considerable significance as frozen forage has not been widely used in bloat research.

A comparison of the nitrogen content of the original forage with that of the orts (table 4) could provide an estimate of the degree of selectivity by the animals for the leafy vs. the stem portions of the plants (Raymond *et al.*, 1955). Judging from the mean nitrogen values of the orts as compared to the forage as fed it is evident that a substantial amount of selection occurred even when the forages were chopped, suggesting that the investigator cannot assume that chopping will automatically eliminate selection. No clear differences between chopped and long, and between fresh and frozen were observed. Very little selection occurred in the case of mature red clover (Trial 3) and birdsfoot trefoil, an indication that there was little difference in acceptability between different parts of the plant of these two species.

It is common observation that grass frozen in the field in the fall of the year may cause scouring of livestock. There was no evidence of such an effect in this study.

Although Raymond *et al.* (1953), showed that freezing did not affect digestibility as measured in the conventional manner, it may be of equal interest in some types of experimentation to know if freezing affects the rate of digestion of the forages. The results of Trial 4, designed to evaluate this point, are shown in figure 1. The dry matter digestion rate of the frozen immature alfalfa was somewhat slower than that of the fresh for the first 6 hours but no differences were apparent after 12 hours. It is reasonable to expect that a certain amount of breakdown of the cellular structure might occur in the freezing process (Woodroof, 1938), thus resulting in a greater surface exposure for microbial action, but there is no evidence of this occurring. The slower initial digestion rate of the frozen forage might be due to such factors as ruminal temperatures, although such were not measured in this study. These results suggest that the feeding of frozen forages did not cause any major disturbance in rate or extent of ruminal digestion.

TABLE 4. NITROGEN CONTENT OF FORAGE FED AND OF ORTS

Forage species	Trial No.	Nitrogen in forages fed (dry matter basis)	Nitrogen in orts (dry matter basis)			
			Long		Chopped	
			Fresh	Frozen	Fresh	Frozen
		%	%	%	%	%
Red clover	1	2.50	2.02	1.99	1.90	2.37
	3	2.43	2.14	2.26	2.14	2.10
Alfalfa	1	2.64	1.76	1.79	1.86	1.93
	3	3.00	2.58	2.34	2.40	2.50
Brome	1	2.04	1.48	1.58	1.79	1.75
Oats	3	2.49	2.01	1.88	1.91	1.84
Orchard grass	1	1.86	1.59	1.67	1.72	1.57
	3	2.67	....	....	2.20	2.11
Birdsfoot trefoil	3	2.17	....	....	2.37	2.16
	Means	2.42[a]	1.94	1.93	1.96[a]	2.01[a]
		2.42	....	....	2.03	2.04

[a] Mean does not include orchard grass and birdsfoot trefoil in Trial 3.

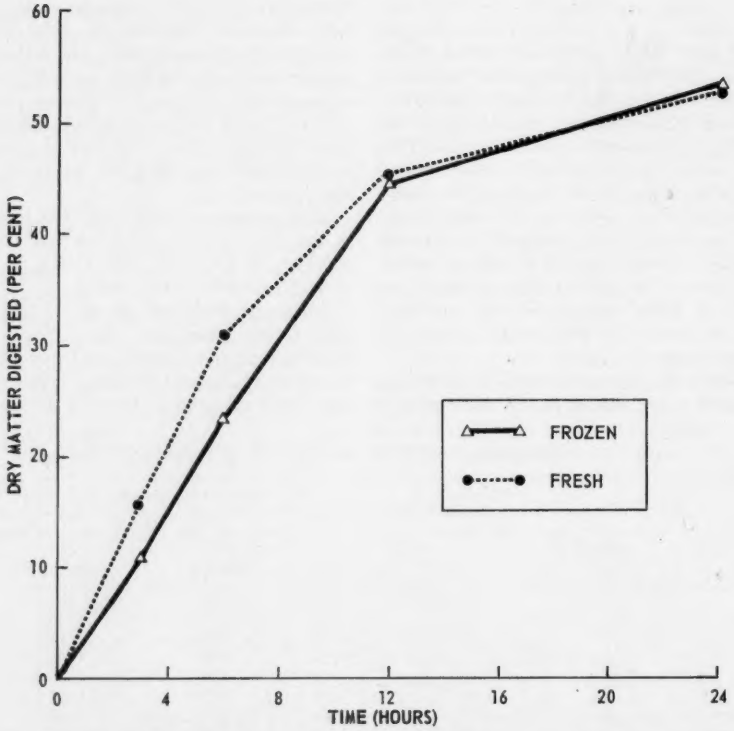

Figure 1. Effect of freezing on the dry matter digestion rate of immature alfalfa in the rumen of steers. Each point on the graph represents the mean from 2 steers each day for 4 days.

Summary

A procedure for preserving green forages by freezing which is suitable for animal experimentation is discussed. Feeding trials with sheep using red clover, alfalfa, brome grass, green oats, orchard grass and birdsfoot trefoil at different stages of maturity failed to show any significant differences in consumption which could be attributed to freezing. Chopping the forages likewise had no significant effect. Animals exhibited some ability to select parts of the plants regardless of whether the forage was fed in chopped or long state. Rate of dry matter digestibilities of frozen forage showed some lag behind that of the fresh forage within the first 6 hours but this difference was overcome within 12 hours. The bloat producing ability of immature alfalfa could be preserved by freezing.

Literature Cited

Crampton, E. W., E. Donefer and L. E. Lloyd. 1960. A nutritive value index for forages. J. Animal Sci. 19:538.

Erwin, E. S. and N. G. Elliston. 1959. Rapid method of determining digestibility of concentrates and roughages in cattle. J. Animal Sci. 18:1518.

Ferguson, W. S. and R. A. Terry. 1955. Bloat investigations. J. Agr. Sci. 46:257.

Joslyn, M. S. and H. C. Diehl. 1952. Physiological aspects of low temperature preservation of plant products. Ann. Rev. Plant Physiol. 3:149.

Mather, R. E., J. W. Bartlett and J. L. Cason. 1956. Different methods of utilizing forages in dairy cattle nutrition. Pasture vs. soiling vs. hay vs. silage. Grass Symposium, A.A.A.S., Washington, D. C. Publ. 53:161.

McAnnally, R. A. 1942. Digestion of straw by the ruminant. Biochem. J. 36:392.

McDougall, D. and W. A. DeLong. 1942. The effect of initial drying temperature on the apparent lignin content of plant tissue. Can. J. Res. (B) 20:40.

Miller, W. J., R. K. Waugh and G. Matrone. 1954. Comparison of the digestibility of certain pasture

forages in the fresh and dried states. J. Animal Sci. 13:283.
Newlander, J. A., H. B. Ellenberger, O. M. Camburn and C. H. Jones. 1940. The conservation of alfalfa, timothy and soybean nutrients as silages and as hays. Vt. Agr. Exp. Sta. Bul. 459.
Raymond, W. F., Dudley E. Eyles and V. G. Caukwell. 1949. Cold storage of pasture used in digestibility experiments. J. Brit. Grassland Soc. 4:111.
Raymond, W. F., C. E. Harris and V. G. Harker. 1953. Studies on the digestibility of herbage. II. Effect of freezing and cold storage of herbage on its digestibility by sheep. J. Brit. Grassland Soc. 8:315.
Raymond, W. F., C. E. Harris and C. D. Kemp. 1955. Studies in the digestibility of herbage. VI. The effect of level of herbage intake on the digestibility of herbage by sheep. J. Brit. Grassland Soc. 10:19.
Spahr, S. L., E. M. Kesler, J. W. Bratzler and J. B. Wasko. 1961. Effect of stage of maturity at first cutting on quality of forages. J. Dairy Sci. 44:502.
Tressler, D. K. and C. F. Evers. 1957. The Freezing Preservation of Foods. Vol. 1, The Avi Publishing Co., Inc., Westport, Conn.
Watson, S. J. and W. S. Ferguson. 1932. Investigations into the intensive system of grassland management. 8. The comparative digestibility and feeding value of fresh and artificially dehydrated grass. J. Agr. Sci. 22:235.
Woodroof, J. G. 1938. Microscopic studies of frozen fruit and vegetables. Ga. Agr. Exp. Sta. Bul. 201.

EFFECT OF LENGTH OF THE FEEDING PERIOD ON ACCURACY OF SELECTION FOR GAIN AND FEED CONSUMPTION IN BEEF CATTLE

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THE accuracy of measuring the genic value of cattle for growth rate and feed efficiency depends in part on the length of the post-weaning feeding period. While the genotypes for gain and feed consumption cannot be measured directly, the accuracy of predicting the genic values of these traits from the phenotypic values observed at the end of the feeding period or at an earlier time may be studied. The relative accuracy of the information available at successive stages during an animal's life is useful for determining the length of the post-weaning period which should be used for measuring these traits. The relative accuracy of selecting for: (1) weight at one year of age, (2) post-weaning gain and (3) post-weaning feed consumption based on various combinations of the information obtained at weaning and in three successive 56-day periods from weaning to a year of age is presented in this paper. Estimates of heritabilities and phenotypic, genetic and environmental correlations among weaning weight, gain and feed consumption in the different periods and linear combinations of the traits are also presented.

Data and Method

The data were obtained from bull and heifer calves in the experimental beef breeding herds located at the Fort Robinson Beef Cattle Research Station, Crawford, Nebraska, and the Nebraska Agricultural Experiment Station, Lincoln. The data were described in detail in an earlier paper (Swiger *et al.*, 1961). Records on 351 calves were available at Lincoln. At Fort Robinson, 741 calves were used in studying post-weaning gain and weaning weight while 660 calves were used to study feed consumption. Weaning weight was computed as birth weight plus 200 times average daily gain from birth to weaning plus an adjustment for differences in the ages of the dams. Gain and feed consumption of each animal were recorded for each of six 28-day periods. As the data on 28-day periods were required for another analysis, they were adjusted for inbreeding of calf and inbreeding of dam at Lincoln and for initial age at both stations, prior to combining them into three 56-day periods for this analysis. Weaning weights of the calves at Lincoln were adjusted for inbreeding also. The inbreeding adjustments used for the Lincoln data and a discussion of why the Fort Robinson data were not adjusted have been reported (Swiger *et al.*, 1961). In order to provide information on two levels of energy intake the calves were fed at a higher level of energy intake at Lincoln than at Fort Robinson. The average daily feed intake, converted to pounds of total digestible nutrients (TDN), was 9.6 at Lincoln and 5.7 at Fort Robinson. At Fort Robinson, the ration consisted primarily of roughage.

The degrees of freedom for the paternal half-sib analyses of variance and covariance among weaning weight and period gains and among feed consumption (TDN) by periods are shown in table 1. Phenotypic and genetic components of variance and covariance were computed from these analyses. The average inbreeding coefficients of the calves and their parents were used in partitioning the phenotypic components into genetic and environmental components. Heritabilities and phenotypic, genetic and environmental correlations among the traits were computed from these components.

The methods used to examine the relative accuracy of information available at various times during the feeding period were first described by Hazel *et al.* (1943) using swine data. These methods have been applied to beef cattle by Knapp and Clark (1947), Urick *et al.* (1957) and Swiger and Hazel (1961). Briefly, the procedure is to compute indexes combining the various sets of traits to be compared. The indexes are linear functions of the traits. They are constructed to maximize the correlation between the index and

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TABLE 1. SOURCES OF VARIATION AND DEGREES OF FREEDOM FOR THE ANALYSES OF VARIANCE AND COVARIANCE

Lincoln		Fort Robinson		
	Degrees of freedom for:		Degrees of freedom for:	
Source of variation	Weaning weight, gain and feed consumption	Source of variation	Weaning weight and gain	Feed consumption
Sexes	1	Sexes	1	1
Years/sexes	8	Years/sexes	7	6
Groups/years	10			
Lines/groups	57	Line/Years	83	72
Sires/lines	47	Sires/lines	39	30
Half-sibs/sires	227	Half-sibs/sires	610	550

the genic value of the trait being predicted by the index. The genic value for a trait is defined as the sum of the average effects of the genes which affect that trait.

Post-weaning gain and feed consumption were defined as 168-day gain and 168-day feed consumption (TDN). Final weight was defined as 200-day weaning weight plus 168-day gain. The indexes are least squares, multiple regression equations computed from the phenotypic and genetic variances and covariances among the traits being combined in the index. The dependent variable is the sum of the average effects of the genes for the trait being predicted i.e., gain, feed consumption or final weight.

The accuracy (r_{IG}) of each index for predicting the dependent variable is the square root of the fraction of the genetic variance in the dependent variable accounted for by the index. This correlation is proportional to the change in the dependent variable expected to result from selection based on the index. The correlation is an appropriate basis for comparing the indexes as it represents the relative rate of change in the genic values for the trait being predicted which can be accomplished by selecting for the set of traits included in the index.

Results and Discussion

Heritabilities and Correlations for Weight and Gain. Phenotypic and genetic variances and covariances for weaning weight, post-weaning gain and final weight, computed from the data are shown in table 2. Estimates of

TABLE 2. PHENOTYPIC AND GENETIC VARIANCES AND COVARIANCES AMONG WEANING WEIGHT, FINAL WEIGHT, GAIN IN THREE SUCCESSIVE 56-DAY PERIODS AND 168-DAY GAIN

Trait		Variance and covariance	Wn. wt.	56-day period gain			168-day gain	368-day wt.
				1	2	3		
				Lincoln				
Wn. wt.		Phen.	1720	23	64	−37	50	1770
		Gen.	−771	−447	−66	−519	−1032	−1803
56-day period gain	1	Phen.	....	397	3	68	468	491
		Gen	....	171	−157	−43	−29	−476
	2	Phen.	....	...	508	152	663	727
		Gen.	....	...	357	323	523	457
	3	Phen.	....	...	...	545	765	728
		Gen.	....	...	...	425	705	186
168-day gain		Phen.	....	...	...	...	1896	1946
		Gen.	....	...	...	...	1199	167
368-day wt.		Phen.	....	...	...	...	....	3716
		Gen.	....	...	...	...	....	−1636
				Fort Robinson				
Wn. wt.		Phen.	1681	32	129	128	289	1970
		Gen.	329	−16	58	334	376	−705
56-day period gain	1	Phen.	....	333	−27	−5	301	333
		Gen.	....	261	−93	−108	60	44
	2	Phen.	....	...	465	20	458	587
		Gen.	....	...	280	139	326	384
	3	Phen.	....	...	...	433	448	576
		Gen.	....	...	...	206	237	571
168-day gain		Phen.	....	...	...	...	1207	1496
		Gen.	....	...	...	...	623	999
368-day wt.		Phen.	....	...	...	...	....	3466
		Gen.	....	...	...	...	....	1704

TABLE 3. HERITABILITIES OF MEASURES OF GROWTH AND THEIR APPROXIMATE STANDARD ERRORS

Trait	Lincoln	Fort Robinson
Weaning wt.	−.45±0.46	0.20±0.30
First 56-day period gain	0.43±0.46	0.78±0.35
Second 56-day period gain	0.70±0.46	0.60±0.33
Third 56-day period gain	0.78±0.46	0.48±0.33
112-day gain	0.23±0.46	0.48±0.33
168-day gain	0.63±0.46	0.52±0.33
256-day wt.	−.69±0.46	0.27±0.31
312-day wt.	−.56±0.46	0.28±0.31
368-day wt	−.44±0.46	0.49±0.33

heritability (table 3) and phenotypic, genetic and environmental correlations (table 4) were computed from these variances and covariances. The heritabilities and correlations other than weaning weight and gain in the three 56-day periods were computed from linear combinations of the components for these four traits.

The components of variance and covariance for the traits and the resulting heritabilities and correlations merit careful examination because the indexes depend entirely on them. In general, if genetic correlations between periods are large or if the heritabilities of later periods are small, the indexes including information from the early periods will be nearly as accurate as indexes including information from all periods.

The estimate of the genetic variance of weaning weight was negative for the Lincoln calves. The approximate standard errors of all the heritabilities were large at both locations. Because sires were sometimes repeated in different years, there were only 17 effective degrees of freedom for sires in the Lincoln analysis. The heritability of weaning weight was 0.20±0.30 for the Fort Robinson data.

TABLE 4. PHENOTYPIC, GENETIC AND ENVIRONMENTAL CORRELATIONS AMONG WEANING WEIGHT, FINAL WEIGHT, GAIN IN THREE SUCCESSIVE 56-DAY PERIODS AND 168-DAY GAIN

Trait		Correlation	56-day period gain 1	2	3	168-day gain	368-day wt.
			Lincoln				
Wn. wt.		Phen	0.03	0.07	−.04	0.03	0.07
		Gen.	....	....	....	....	....
		Env.	....	....	....	....	....
56-day period gain	1	Phen.	....	0.01	0.15	0.54	0.40
		Gen.	....	−.63	−.16	−.06	....
		Env.	....	0.87	0.67	1.26	....
	2	Phen.	....	....	0.29	0.68	0.53
		Gen.	....	....	0.83	0.80	....
		Env.	....	....	−1.26	0.43	....
	3	Phen.	....	....	....	0.75	0.51
		Gen.	....	....	....	0.99	....
		Env.	....	....	....	0.21	....
168-day gain		Phen.	....	....	....	....	0.73
		Gen.	....	....	....	....	....
		Env.	....	....	....	....	....
			Fort Robinson				
Wn. wt.		Phen.	0.04	0.15	0.15	0.20	0.82
		Gen.	−.05	0.19	1.28	0.83	0.94
		Env.	0.15	0.14	−.37	−.10	0.82
56-day period gain	1	Phen.	....	−.07	−.01	0.48	0.31
		Gen.	....	−.34	−.46	0.15	0.07
		Env.	....	0.57	0.80	1.66	0.81
	2	Phen.	....	....	0.04	0.61	0.46
		Gen.	....	....	0.58	0.78	0.56
		Env.	....	....	−.58	0.40	0.36
	3	Phen.	....	....	....	0.62	0.47
		Gen.	....	....	....	0.66	0.96
		Env.	....	....	....	0.58	0.01
168-day gain		Phen.	....	....	....	....	0.73
		Gen.	....	....	....	....	0.97
		Env.	....	....	....	....	0.49

The heritability of 56-day gains increased in successive periods at Lincoln. At Fort Robinson these heritabilities decreased for each successive period. Swiger (1961) found decreasing heritabilities for successive 28-day periods after the first period. Knapp and Clark (1947) reported increasing heritabilities for three successive 84-day periods.

Unfortunately no clear pattern of the changes in the relation between genetic and phenotypic variance through the post-weaning period emerges from the analysis of the large amount of data represented in these four studies. Differing environmental conditions at the four locations could account for at least part of this. The environmental relationships between the first month after weaning, for example, and other time periods probably are not the same at different locations. Different weaning dates, climatic conditions and management practices might affect these relationships.

The heritabilities of 112- and 168-day gain were in some instances smaller than the heritabilities of the separate periods, because the genetic covariances were generally lower than the phenotypic covariances. The heritabilities of the post-weaning weights were negative at Lincoln because of the large negative genetic variances for weaning weight and the negative genetic covariances of weaning weight with gain in the post-weaning periods. The heritability of successive post-weaning weights for Fort Robinson increased because the genetic covariances involved were generally larger than the phenotypic covariances.

The phenotypic correlations of weaning weight with post-weaning gain were small but usually positive for both stations (table 4). The phenotypic correlations between weaning weight and final weight were usually large because weaning weight is part of final weight. The phenotypic correlations among gain in the three periods were small. However, gain in each period was a good indicator of total gain and final weight.

Since the genetic variance of weaning weight was negative at Lincoln, genetic correlations between weaning weight and post-weaning gain were not computed. However, these genetic covariances were negative. The negative estimate of the heritability of weaning weight found at Lincoln and the negative genetic relationships of weaning weight with post-weaning gain cast serious doubt on the usefulness of the Lincoln data for this study. The pattern of genetic and environmental relationships derived using the Lincoln data was not in agreement with the other studies cited. Also, these genetic relationships between the post-weaning periods are inconsistent with the relationships of the post-weaning periods with weaning weight. The genetic covariance between weaning weight and gain in each 56-day post-weaning period was negative. The genetic correlation between the second and third periods was positive yet this correlation was negative for each of these periods with the first period. The environmental covariances between adjacent periods in some cases had large positive values. Variation in fill, errors in weighing and compensatory effects usually cause negative environmental correlations between adjacent periods. The environmental covariances are obtained by subtraction and thus reflect the same disagreement between the Lincoln data and the other studies as do the genetic relationships. The genetic and environmental correlations computed from these components have extremely large sampling errors.

In the Fort Robinson data the genetic correlations were —.05, 0.19 and 1.28 between weaning weight and the three 56-day periods. When computed from variance components, genetic or environmental correlations in excess of unity can occur due to sampling error. The genetic correlations were negative for the first with the other two periods but positive between the last two periods. The genetic relationships among the post-weaning periods were similar to those found in the Lincoln data. In the Fort Robinson data these relationships were consistent with the genetic relationships of the post-weaning periods with weaning weight.

Swiger (1961) reported positive genetic correlations between weaning weight and post-weaning gains and among gains in the post-weaning periods. All genetic correlations between gains made in different periods were positive in studies of Knapp and Clark (1947). Koch and Clark (1955) reported a negative genetic correlation between weaning weight and post-weaning gain (—.03). Carter and Kincaid (1959) found large genetic correlations between weaning weight and post-weaning gain for steers (0.66) and heifers (0.51). No negative genetic covariances between post-weaning periods have been reported. Genetic correlations of period gains with total gain at both stations and with final weight at Fort Robinson had large positive values except for the first period.

Environmental correlations tended to be large and opposite in sign to the genetic correlations since the phenotypic correlations were generally small and the environmental covariances were obtained by subtraction. Part-whole relationships were usually large. Swiger (1961) found negative environmental relationships between adjacent periods. These relationships became nearer zero and then positive as the time between periods increased. Knapp and Clark (1947) reported negative or small positive environmental correlations between adjacent 84-day periods.

Indexes Involving Weight and Gain. The indexes used to estimate the genic value for a trait depend entirely on the phenotypic and genetic variances and covariances among the traits included in the index. Results obtained from computing the indexes must be interpreted in light of the foregoing discussion of the components.

TABLE 5. PARTIAL REGRESSIONS FOR THE INDEXES PREDICTING 168-DAY POST-WEANING GAIN (I′) AND 368-DAY WEIGHT (I)

Index	Wn. wt.	56-day period gain 1	2	3	r_{GI}[a]
		Lincoln			
I'_2	..	−.07	..	..	0.04
I'_3	..	..	1.03	..	0.67
I'_4	..	..	..	1.29	0.87
I'_5	..	−.08	1.03	..	0.67
I'_6	..	−.27	0.69	1.13	0.99
		Fort Robinson			
I'_1	0.22	..	..	..	0.37
I'_2	..	0.18	..	..	0.13
I'_3	..	..	0.70	..	0.60
I'_4	..	..	..	0.55	0.46
I'_5	..	0.24	0.71	..	0.63
I'_6	..	0.24	0.69	0.52	0.77
I_1	0.42	..	..	..	0.42
I_2	..	0.13	..	..	0.06
I_3	..	..	0.83	..	0.43
I_4	..	..	..	1.32	0.66
I_5	0.42	0.09	..	..	0.42
I_6	0.36	0.16	0.74	..	0.56
I_7	0.27	0.25	0.71	1.21	0.83

[a] Correlation between index and genic value for post-weaning gain or final weight.

The indexes predicting the genic value for 168-day post-weaning gain (I′) and final weight (I) are given in table 5. For example, $I_5 = 0.42$ (weaning weight) + 0.09 (first period gain). Indexes predicting the genic values for gain are shown for each trait separately and for combinations of traits as they would become available with time. The second and third gain periods were good indicators of total gain at both stations while the first period was not. At both stations, adding an additional period (I'_2 vs. I'_5 and I'_5 vs. I'_6) increased the correlations substantially although adding the last period increased the correlation less at Fort Robinson than at Lincoln. At Fort Robinson the correlation between weaning weight and the genic value for 168-day gain (I′) was 0.37.

Weaning weight alone and gain in each of the last two periods were highly related to the genic effects for final weight at Fort Robinson. Accuracy was gained by adding successive periods except that weaning weight alone appears to be as good as including gain in the first 56 days. Little information was obtained from the first period because its total genetic covariance with final weight was reduced by the negative relationships with the other traits (table 2).

Examination of these indexes indicates that the post-weaning feeding period should be at least 168-days in lengths for predicting the genic effects for either 168-day gain or 368-day weight. The results of Swiger and Hazel (1961) indicated that combining weaning weight and gain in an 84-day period in an index gave about 95% as much information about the genic effects for 140-day gain and 12-month weight as did combining weaning weight and gain in the entire 140-day post-weaning period. In their data the calves were on a full feed or high concentrate ration comparable to the Lincoln calves in this study. At Fort Robinson the level of energy intake was considerably lower. Evaluation of genetic differences in gain might require a longer feeding period under limited energy intake than under full feeding if the full genetic potential for growth is inhibited by feeding a low energy ration.

Heritabilities and Correlations for Feed Consumption. Phenotypic and genetic variances and covariances for feed consumption computed from the data are shown in table 6. Estimates of heritability (table 7) and phenotypic, genetic and environmental correlations (table 8) were computed from these variances and covariances. The heritabilities of feed consumption by periods (like gain by periods) increased through the post-weaning period at Lincoln and decreased at Fort Robinson. The heritabilities of 112-day and 168-day feed consumption were smaller than the heritabilities of some 56-day periods because the genetic covariances were less than the phenotypic covariances between periods.

Genetic correlations between feed consumption in various periods had positive values except the one between the first two periods at

TABLE 6. PHENOTYPIC AND GENETIC VARIANCES AND COVARIANCES AMONG FEED CONSUMPTION IN THREE SUCCESSIVE 56-DAY PERIODS AND 168-DAY FEED CONSUMPTION

Trait		Variance and covariance	56-day period feed consumption 1	2	3	168-day feed consumption
			Lincoln			
56-day period feed consumption	1	Phen.	2868	1921	2079	6868
		Gen.	389	—133	574	830
	2	Phen.	....	3872	3734	9527
		Gen.	....	574	2968	3409
	3	Phen.	....	....	6889	12702
		Gen.	....	....	5336	8878
168-day feed consumption		Phen.	....	....	....	29097
		Gen.	....	....	....	13117
			Fort Robinson			
56-day period feed consumption	1	Phen.	1754	1441	1199	4394
		Gen.	997	998	614	2609
	2	Phen.	....	3263	2852	7556
		Gen.	....	1399	947	3344
	3	Phen.	....	....	4876	8927
		Gen.	....	....	509	2070
168-day feed consumption		Phen.	....	....	....	20877
		Gen.	....	....	....	8023

Lincoln (table 8). Environmental correlations were also large and positive suggesting compensatory consumption was not the primary environmental factor affecting this relationship. Correlations of 56-day feed consumption with total 168-day feed consumption were generally large, being part-whole relationships.

Indexes Involving Feed Consumption. The indexes predicting the genic value for 168-day post-weaning feed consumption are given in table 9. Indexes are shown for each period separately (I_1 to I_3) and for the first and second and first, second and third periods combined (I_4 and I_5). For Lincoln, adding successive periods increased the correlation from 0.14 to 0.51 and then 0.99. This suggests that considerably more information about the genotype for feed consumption is

TABLE 7. HERITABILITIES OF FEED CONSUMPTION FOR SUCCESSIVE 56-DAY PERIODS, 112 DAYS, AND 168 DAYS AND THEIR APPROXIMATE STANDARD ERRORS

Trait	Lincoln	Fort Robinson
First 56-day period feed consumption	0.14±0.46	0.57±0.38
Second 56-day period feed consumption	0.15±0.46	0.43±0.37
Third 56-day period feed consumption	0.77±0.46	0.10±0.33
112-day feed consumption	0.07±0.45	0.56±0.38
168-day feed consumption	0.45±0.46	0.38±0.36

TABLE 8. PHENOTYPIC, GENETIC AND ENVIRONMENTAL CORRELATIONS AMONG FEED CONSUMPTION IN THREE 56-DAY PERIODS AND 168-DAY FEED CONSUMPTION

Trait		Correlation	56-day period feed consumption 2	3	168-day feed consumption
			Lincoln		
56-day period feed consumption	1	Phen.	0.58	0.47	0.75
		Gen.	—.28	0.40	0.37
		Env.	0.72	0.77	0.96
	2	Phen.	....	0.72	0.90
		Gen.	....	1.69	1.24
		Env.	....	0.34	0.84
	3	Phen.	....	....	0.90
		Gen.	....	....	1.06
		Env.	....	....	0.77
			Fort Robinson		
56-day period feed consumption	1	Phen.	0.60	0.41	0.81
		Gen.	0.93	0.86	0.92
		Env.	0.37	0.32	0.57
	2	Phen.	....	0.72	0.92
		Gen.	....	1.24	1.10
		Env.	....	0.67	0.86
	3	Phen.	....	....	0.89
		Gen.	....	....	1.02
		Env.	....	....	0.91

TABLE 9. PARTIAL REGRESSIONS FOR THE INDEXES PREDICTING 168-DAY POST-WEANING FEED CONSUMPTION

Index	56-day period feed consumption 1	2	3	r_{GI}[a]
		Lincoln		
I_1	0.29	....	....	0.14
I_2	....	0.88	....	0.48
I_3	....	....	1.29	0.93
I_4	—.45	1.10	....	0.51
I_5	—.66	—.48	1.74	0.99
		Fort Robinson		
I_1	1.49	....	....	0.70
I_2	....	1.02	....	0.65
I_3	....	....	0.42	0.33
I_4	1.01	0.58	....	0.75
I_5	1.00	0.88	—.33	0.78

[a] Correlation between index and genic value for post-weaning feed consumption.

added with the addition of each 56-day period.

For Fort Robinson, adding successive periods increased the correlation from 0.70 to 0.75 and to 0.78. Feed consumption in the first 56 days was 0.90=(0.70/0.78) as efficient for predicting the genic value for 168-day feed consumption as was feed consumption in each of the three periods combined in the most efficient way. Comparing the results from Fort Robinson for gain and feed consumption indicates that more of the information about the genic effects for feed consumption can be obtained early in the feeding period than for gain. Errors in weighing would be expected to be more important for measuring gain than feed consumption. In addition, variation in fill contributes to the errors involved in weighing cattle. Whether it would be practical to terminate the period of individual feeding prior to the end of the period for evaluating gain would depend on the variable costs of the particular feeding operation. If labor costs were large it might be advisable to utilize a short period. On the other hand, it might be desirable to continue individual feeding to the end of the gain evaluation period in highly mechanized operations.

Summary and Conclusions

Weaning weight and gain in three successive 56-day periods were combined in indexes predicting the genic effects for 368-day weight and for 168-day feed lot gain. Feed consumption in the three 56-day periods was used to predict the genic effects for 168-day post-weaning consumption.

The indexes predicting the genic effects for 168-day gain and feed consumption computed from the Lincoln data indicated that accuracy would be increased for both traits by including information from the entire 168-day test. Results of the Fort Robinson analysis also indicate that the additional information about the genic values for final weight and feed lot gain which resulted from adding subsequent 56-day periods to the index was sufficient to justify feeding at least 168-days. In the analyses of feed consumption in three 56-day periods at Fort Robinson, the first period was 90% as accurate in predicting the genic effects for feed consumption as was an index combining all three periods in the most efficient way.

The results of the analyses of two herds of beef cattle in this study and similar studies by Knapp and Clark (1947) and Swiger and Hazel (1961) are inconsistent. The estimates of the parameters needed to examine the problem have high sampling errors. While inadequacies in certain results can be pointed out and opinions may be formed, it is not possible to reconcile completely the different results obtained from the four herds. Therefore, general recommendations on the length of the post-weaning period for evaluating gain and feed consumption over a wide range of environments and management practices cannot be made at this time.

Literature Cited

Carter, R. C. and C. M. Kincaid. 1959. Estimates of genetic and phenotypic parameters in beef cattle. III. Genetic and phenotypic correlations among economic characters. J. Animal Sci. 18:331.

Hazel, L. N., Marvel L. Baker and C. F. Reinmiller. 1943. Genetic and environmental correlations between the growth rates of pigs at different ages. J. Animal Sci. 2:118.

Knapp, Bradford, Jr. and R. T. Clark. 1947. Genetic and environmental correlations between growth rates of beef cattle at different ages. J. Animal Sci. 6:174.

Koch, Robert M. and R. T. Clark. 1955. Genetic and environmental relationships among economic characters in beef cattle. I. Correlations among paternal and maternal half-sibs. J. Animal Sci. 14:775.

Swiger, L. A. 1961. Genetic and environmental influences on gain of beef cattle during various periods of life. J. Animal Sci. 20:183.

Swiger, L. A., K. E. Gregory, Robert M. Koch and V. H. Arthaud. 1961. Effect of inbreeding on performance traits of beef cattle. J. Animal Sci. 20:626.

Swiger, L. A. and L. N. Hazel. 1961. Optimum length of feeding period in selecting for gain of beef cattle. J. Animal Sci. 20:189.

Urick, J., A. E. Flower, F. S. Willson and C. E. Shelby. 1957. A genetic study in steer progeny groups during successive growth periods. J. Animal Sci. 16:217.

EFFECT OF GRAIN FEEDING THE EWE AND LAMB ON SUBSEQUENT LAMB GROWTH

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THE practice of grain feeding lactating ewes is one followed by many producers of early spring lambs. They contend that grain feeding increases milk production and extends the length of the lactation period. This observation is borne out by Coop (1950), who concluded that the nutritive level of the ewe during lactation had more effect on lamb growth than nutritive level during late pregnancy. However, Matthews and Madsen (1960) reported that creep-fed lambs suckling ewes fed 1 lb. of barley per ewe daily and free-choice alfalfa hay gained at about the same rate as creep-fed lambs suckling ewes that received no supplemental grain feeding. Jordan *et al.* (1959) reported that creep-fed lambs, weaned at about 12 weeks of age, weighed as much at 20 weeks as creep-fed lambs that were not weaned. The necessity of maintaining heavy milk production for relatively long periods of time is of less importance when lambs are weaned early. The objective of this study was to investigate the effects of supplemental grain feeding of both the ewe and the lamb upon subsequent lamb growth.

Procedure

Suckling lambs produced by Rambouillet, Shropshire and Hampshire ewes were used as test animals. In each experiment the ewes and their 3-week-old lambs were randomly assigned to treatments from outcome groups based on breed and age of the ewes and weight, sex and type of birth (single or twin) of the lamb. In 1959, seven single lambs and three sets of twin lambs were assigned to each treatment. Initial weight of the lambs was 19–20 lb. In 1960, five single lambs and five sets of twins that averaged 20–22 lb. were assigned to each treatment. In 1959, the ewes on all treatments received equal amounts of the basal roughage ration consisting of alfalfa hay and corn silage. In 1960, the basal roughage ration consisted of alfalfa hay and was fed in equal amounts to all ewes.

Treatments were as follows: Treatment 1, the ewes were fed the basal roughage ration (no grain, no creep); Treatment 2, the ewes were fed the basal roughage ration plus 1 lb. shelled corn per ewe daily and their lambs were not creep-fed (grain, no creep); Treatment 3, the ewes were fed the basal roughage ration and their lambs had access to creep-feed (no grain, creep); Treatment 4, the ewes were fed the basal roughage ration plus 1 lb. shelled corn per ewe daily and in addition, their lambs were creep-fed (grain-creep). In all treatment groups the lambs had access to the ewes' ration. Lambs in Treatments 1 and 2 ate some of the ewes' ration though the amount was not determined.

In 1959, the creep-feed consisted of a mixture of 90% cracked corn, 10% soybean oil meal and antibiotics with alfalfa hay available in the creep. In 1960, the creep ration was pelleted and contained 30% alfalfa hay and a mixture of oats, bran, soybean oil meal and corn and was fortified with minerals, antibiotics and vitamin A and D. The ewes were housed in a shed with open doors on the south side and had access to small outside lots. Fresh water and a salt-bone meal mixture was available at all times. The ewes were individually weighed at the beginning and the end of the experiment and the lambs were individually weighed at 2-week intervals.

Because of the differential survival rate of lambs in the various pens, subclass numbers were disproportionate (table 1) although the disproportionality was not great. Since the creep-fed rations were pelleted the second year (creep 2) but not the first (creep 1), an ordinary analysis of variance taking these differences into account was not possible. A complete least squares solution was determined for the treatment effects using a method outlined by Harvey (1960). Since in the analysis creep feeding each year was considered a separate treatment, the method involved 6, rather than 4, treatments. There-

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TABLE 1. EFFECT OF GRAIN FEEDING EITHER THE EWE OR THE LAMB ON LAMB GROWTH

Item	Exp. no.	Treatments [a] 1 No grain No creep	2 Grain No creep	3 No grain Creep	4 Grain Creep
No. days	1	62	62	62	62
	2	66	66	66	66
No. lambs	1	13	12	12	13
	2	15	14	14	14
Av. initial wt., lb.	1	19.1	19.6	20.0	19.9
	2	22.3	21.8	22.4	20.6
Daily gain, lb.	1	0.36	0.46	0.61	0.64
	2	0.32	0.45	0.71	0.80
Average	1 and 2	0.34	0.45	0.66	0.72
Daily creep fed, lb.	1	....	....	1.00	.84
	2	....	....	1.50	1.54
Daily ewe feed [b]	1	7.4	8.4	7.4	8.4
	2	5.7	6.5	5.7	6.4
Feed per pound of [c] 8 gain, lb.	1	15.9	13.3	11.7	11.1
	2	11.8	10.3	7.8	7.8
Ewe's wt. change, lb.	1	−8.0	8.0	−5.0	11.0
	2	−13.0	7.0	−7.0	9.0

[a] Grain and creep combination for ewes and lambs.
[b] Difference in daily feed consumption is due to 1.0 lb. of corn fed daily to ewes in treatments 2 and 4.
[c] Feed per lb. of gain includes all feed fed the ewes as well as the creep feed fed the lambs. All feed consumed is charged against the lamb gains.

fore 5 independent and meaningful comparisons were made among these 6 treatments (no grain, no creep; grain, no creep; creep 1, no grain; creep 1, grain; creep 2, no grain and creep 2, grain).

Results

The results of the two experiments are presented in table 1. Grain feeding of neither the ewe nor the lamb (Treatment 1) resulted in the slowest daily gain each year. The 2-year average was 0.34 lb. per lamb daily. Lambs that were not creep fed but suckled ewes who were grain fed (Treatment 2) made next to the slowest average daily gains each year. Their 2-year average daily gain was 0.45 lb. Creep-fed lambs suckling ewes that were not fed grain (Treatment 3) made the second fastest gains (2-year average, 0.66 lb. per lamb daily). During both years creep feeding the lambs and grain feeding the ewes (Treatment 4) resulted in the fastest average daily gain of any of the treatments (2-year average, 0.72 lb. per lamb daily). In table 1 the 2-year average for daily gain of lambs in Treatments 3 and 4 do not consider the difference in creep feed 1 and creep feed 2.

Analysis of the gain data (table 2) for treatment comparisons indicate that grain feeding of the ewe is independent of creep feeding of the lamb as measured by lamb gains. Since both treatments were beneficial, maximum gain will be achieved by a combination of the two treatments. Grain feeding the ewe (Treatments 2 and 4) increased lamb gains significantly ($P<0.05$). Creep feeding (Treatments 3 and 4) increased lamb gains significantly ($P<0.025$). These results are not in complete agreement with either Matthews and Madsen (1960) or Baird and Sell (1959) who reported that supplemental grain feeding of the ewe did not significantly increase lamb gains when adequate lamb feed was available as a creep feed or high quality pasture. It should be noted, however, that while either grain feeding of the ewe or creep feeding of the lamb increased daily gains of the suckling lambs, creep feeding *per se* increased daily gains to a far greater degree than did grain feeding *per se*. Therefore if a choice between either grain feeding of the ewe or creep feeding of the lamb must be made, creep feeding should be favored.

Creep-feed consumption in 1960 was appreciably higher than in 1959. This greater feed consumption, coupled with the fact that the creep feed was pelleted, may account for the

TABLE 2. MEANS OF DAILY GAIN OF LAMBS

Ewes fed	Exp. no.	Lambs fed: Creep 1	Creep 2	No creep	Mean [a]
Grain	1	0.64	....	0.46	....
	2	....	0.80	0.45	....
Mean [a]		0.64	0.80	0.46	0.59
No Grain	1	0.61	....	0.36	....
	2	....	0.71	0.32	....
Mean [a]		0.61	0.71	0.34	0.50
Mean [a] for both experiments		0.62	0.76	0.40	....

[a] Means are unweighted.

TABLE 3. ANALYSIS OF VARIANCE OF DAILY GAIN OF LAMBS

Source of variation	d.f.	Mean square
Experiments	1	0.137
Treatments:		
Grain	1	50.056
Creep	1	701.059**
Creep 1 vs. creep 2	1	65.267*
Grain vs. creep	1	0.008
Grain x creep 1 vs. creep 2	1	3.295
Experimental error	1	0.216
Within	99	1.695

* $P<.05$
** $P<0.25$

significantly faster gains ($P<0.05$) made by the creep fed lambs in 1960.

During the course of both experiments it was very apparent that the lambs in Treatment 2 (grain, no creep) were eating considerable amounts of the grain that was fed the ewes. This may explain why these lambs gained appreciably faster than the lambs in Treatment 1 (no grain, no creep). Furthermore this may explain, at least in part, why the statistical analysis resulted in a significant increase in lamb gains when the ewes were fed grain.

Ewes grain-fed increased in body weight during the lactation period. Ewes not fed grain lost weight, with the greatest loss occurring among the ewes suckling lambs that were not creep-fed.

Creep feeding the lambs resulted in an appreciable saving in feed required to produce a pound of lamb gain. Due to the low gains made by the lambs suckling ewes that received only roughage, they required the greatest amount of feed per 100 lb. gain (table 1).

Summary

The experiments with suckling lambs were conducted to determine the effect of grain feeding the ewe and/or creep feeding the lambs on lamb gains. Both creep feeding the lambs and grain feeding the lactating ewes increased lamb gains significantly.

The treatments ranked in descending order with respect to weight gains as follows: (1) the combination of grain feeding of the ewes and creep feeding of the lambs; (2) no grain feeding plus creep feeding; (3) grain feeding and no creep feeding; (4) no grain feeding and no creep feeding. A complete pelleted creep feed fed in Experiment 2 resulted in significantly faster gains than a grain-long hay creep feed fed in Experiment 1.

Literature Cited

Baird, D. M. and O. E. Sell. 1959. Spring lamb production practices with winter and temporary pastures in Georgia. Ga. Agr. Exp. Sta. Bul. N. S. 63.

Coop, I. E. 1950. The effect of level of nutrition during pregnancy and during lactation on lamb and wool production of grazing sheep. J. Agr. Sci. 40:311.

Harvey, W. R. 1960. Least squares analysis of data with unequal subclass numbers. U.S.D.A., ARS 20–8.

Jordan, R. M., H. E. Hanke and D. E. Reimer. 1959. The early weaning of lambs. Feedstuffs. May 9, 1959.

Matthews, Doyle J. and Milton A. Madsen. 1960. Farm flock lamb creep feeding test. J. Animal Sci. 19:852.

COMPONENTS OF VARIANCE ASSOCIATED WITH MILK AND FAT RECORDS OF ARTIFICIALLY SIRED HOLSTEIN DAUGHTERS

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COMPONENTS of variance have been used widely in genetic and animal breeding applications. Some earlier reports of these techniques were by Lush *et al.* (1934), Bywaters (1937), Stonaker and Lush (1942), and Baker *et al.* (1943). Important animal breeding applications of variance component estimates are:

(1) to predict the breeding values of sires or dams and to predict real producing abilities of cows,
(2) to indicate sources of variation which should be considered in analyzing production records,
(3) to aid in the establishment of progeny testing programs, including design of the test, number of progeny required, and effectiveness of such programs, and
(4) to direct attention to sources of genetic by genetic, genetic by environmental, and environmental by environmental interactions which should be considered in the above programs.

The purpose of this paper is to present estimates of sire, herd, year-season, and interaction components of variance for first and second milk and fat DHIA records and Owner-Sampler milk and fat records of artificially sired (AI) Holstein daughters.

Data

The data used in this study were first and second lactation, 305-day, 2x, M.E., DHIA milk and fat records of daughters of Holstein AI sires which were available at the New York Dairy Records Processing Laboratory. First records were defined to be those initiated prior to 35 months of age. Second records were defined to be either those started between 35 and 46 months of age, if no record was available in the files which was started prior to 35 months of age, or those started less than 14 months after a previous record which had started prior to 35 months of age. These arbitrary restrictions had to be imposed because lactation number was not available for these records. The third group of records analyzed were Owner-Sampler records of Holstein AI daughters. No attempt was made to divide these records according to lactation number, but only the first centrally processed record per daughter was included in the analysis.

The data were classified by the year-season of calving, sire of the daughter making the record and the herd in which the record was made. Years were divided into three seasons —season one, December through March; season two, April through July; and season three, August through November. Sire groups were limited to those having 10 or more DHIA daughter records in the AI sire file of the Dairy Records Processing Laboratory as of September 1960. This restriction does not imply that 10 daughter records of each sire were included in each analysis. Some of the 10 records may have been first records, others second records, and still others neither a first nor a second record. No restrictions were placed on number of records per herd.

Analysis Procedure

The mathematical model [model II of Eisenhart (1947)] assumed for each record was:

$$Y_{ijkm}=\mu+(s)_i+(y)_j+(h)_k+(sy)_{ij}+(sh)_{ik}+(yh)_{jk}+(syh)_{ijk}+(e)_{ijkm}$$
$$(i=1, \ldots, I;\ j=1, \ldots, J;\ k=1, \ldots, K;\ \text{and } m=1, \ldots, n_{ijk})$$

where Y_{ijkm} is the record of the m^{th} daughter of the i^{th} sire made during the j^{th} year-season in the k^{th} herd, μ is the fixed underlying population mean, and the $(s)_i$, $(y)_j$, $(h)_k$, $(sy)_{ij}$, $(sh)_{ik}$, $(yh)_{jk}$, $(syh)_{ijk}$, and $(e)_{ijkm}$ are assumed to be independent and uncorrelated random effects with means zero and respective variances σ^2_s, σ^2_y, σ^2_h, σ^2_{sy}, σ^2_{sh}, σ^2_{yh}, σ^2_{syh} and σ^2_e. The $(s)_i$, $(y)_j$, and $(h)_k$ refer to the effect of the i^{th} sire, j^{th} year-season, and k^{th} herd, respectively. Interaction effects are denoted similarly. The estimation procedure followed

TABLE 1. SUBCLASS NUMBERS FOR THE COMPONENT OF VARIANCE ANALYSES OF FIRST AND SECOND DHIA RECORDS AND OF OWNER-SAMPLER RECORDS

	First records	Second records	Owner-sampler records
Total number of records	39728	37218	4068
Number of sires	236	230	182
Number of year-seasons	27	27	8
Number of herds	3932	3847	571
Number of sire by year-season subclasses	1881	1785	631
Number of sire by herd subclasses	28981	26661	3248
Number of herd by year-season subclasses	19048	19142	1323
Number of sire by year-season by herd subclasses	36525	34730	3674

Method One described by Henderson (1953). The assumptions given in the model are necessary for the property of unbiasedness to hold for the estimates. Although the year-season effects could easily be considered fixed effects, the complexity of the computations required to obtain unbiased estimates under these assumptions [(see Method Three of Henderson (1953)] led to the decision to use the random model even though all the requirements may not be quite satisfied.

The number of sire, herd, year-season, sire by herd, sire by year-season, herd by year-season, and sire by herd by year-season subclasses are given in table 1 for first records, second records and Owner-Sampler records.

Results and Discussion

First, a consideration of causes of the effects described in the model should be mentioned. The sire component of variance is composed of additive genetic variance plus additive by additive, additive by additive by additive, etc. types of genetic variance. The year-season component is made up mainly of environmental contributions having as its genetic portion only that due to trend in genetic merit. The herd component of variance may be composed of both genetic and environmental portions.

The interaction components are slightly more complex in their interpretation. The sire by year-season component can be considered a genetic by environmental interaction if genetic trend is negligible. In other words, the differences between sires may be different under different weather, temperature, or feed supply conditions. The sire by herd variance component would be associated with a failure of the sire differences to be the same under different herd conditions. The possibility of herd by year-season interaction can be easily visualized. For example, all herds are not apt to react similarly to drough or low milk prices. The economic reserve of the dairyman may affect his reaction to these contingencies. The more economically stable owner is able to buy more and better feedstuffs and for a longer time in case of dry periods than a less prosperous owner who would cut back sooner on his purchases in order to balance costs against income. An interpretation of the three-way interaction component would be that sire by herd interactions are not the same for all year-seasons.

The percents of the total variation accounted for by each of the estimated variance components of first and second milk and fat DHIA records and milk and fat Owner-Sampler records are given in table 2. It is noticed

TABLE 2. ESTIMATED PERCENTAGES OF TOTAL VARIATION OF FIRST AND SECOND DHIA RECORDS AND OWNER-SAMPLER RECORDS CONTRIBUTED BY SIRE, YEAR-SEASON, HERD, AND INTERACTION COMPONENTS OF VARIANCE[a]

Estimated component of variance	First records		Second records		Owner-sampler records	
	Milk	Fat	Milk	Fat	Milk	Fat
σ^2_s	5.89	6.55	5.91	−6.77	2.77	1.79
σ^2_y	2.08	2.59	1.71	2.31	1.56	1.83
σ^2_h	29.14	31.72	28.22	30.40	29.76	30.80
σ^2_{sy}	−0.75	−1.33	−0.43	−1.03	2.12	3.15
σ^2_{sh}	0.41	0.64	2.56	1.21	5.00	6.59
σ^2_{yh}	6.86	8.50	5.95	6.74	5.55	5.70
σ^2_{syh}	6.87	3.50	2.31	1.05	7.24	2.82
σ^2_e	49.51	47.84	53.78	52.55	46.00	47.32
Total variance	68,220.50[a]	9,135.93	72,819.67[a]	10,123.13	61,665.25[a]	8,364.13

[a] Milk records were coded to the nearest 10 lb.

immediately that the total variances of milk and fat records are composed of about the same percents of the different variance components. There is also much similarity between first and second records. If selection on first records of the AI daughters were practiced within herds then it would be expected that the variance of second records would be smaller than first records. Actually, the reverse is true in this analysis although the differences are not large. This result seems to indicate that variance component estimation in this AI population would not need to consider whether records were first records or second records.

The Owner-Sampler variance component analysis shows a slightly different picture. Total variance, especially of milk records, is much lower than for the DHIA records. Some differences also occur in the partitioning of the variance into components, but these may be due to sampling errors resulting from small numbers. It is certain that the sampling variances of the components estimated from the Owner-Sampler records are much larger than those from the other analyses, since only one-tenth as many observations were available. There is, however, general agreement between the three analyses for the portions of variation contributed by herd effects and random error effects.

The estimates of variance components in the DHIA data agree well with those of other workers, e.g., Hickman and Henderson (1955) who, however, did not estimate the sire by year-season and sire by herd by year-season components. Their study included records of 3,912 cows in 1,094 herds by 126 sires. The contribution of the sire component to the total variance of about 6% in this study is in general agreement with the reports of Hickman and Henderson (1955) and Legates *et al.* (1956). The year-season contribution of about 2% is slightly lower than reported earlier. Of the attributable portions of total variance the herd component is the largest, accounting for about 30% of the total variation.

The two-way interactions involving sire effects, σ^2_{sy} and σ^2_{sh}, are estimated to be nearly zero. Legates *et al.* (1956) as well as Hickman and Henderson (1955) have reported the sire by herd component to be negligible. The result of the present analysis tends to confirm the contention of Legates *et al.* (1956), that "nicking" effects probably are not important since these effects are likely to be included in the herd genetic by sire genetic interaction. Johnson *et al.* (1940) and Seath and Lush (1940) found little evidence to support the theory that "nicking" effects are important in dairy cattle breeding. Heizer *et al.* (1938), however, have reported otherwise. The year-season by herd interaction component is sizeable—about the same magnitude as the sire component. Possible reasons for this have been discussed above. Part of this component may be attributable to herd genetic by year-season variation but it would seem more likely to be a result of herd environmental by year-season environmental variation.

The three-way interaction component appears not to have been measured as consistently as the other components. One value—first milk records—is quite large. The other estimates are relatively small. If, in fact, the three-way interaction is important this would indicate that sire proofs under certain environmental conditions (specific herds in specific year-seasons) would be different from proofs under other environmental conditions. Actually, it seems more plausible that the sampling variances of the three-way interaction components are large (the average number of observations per filled three-way subclass was about 1.1) which could easily contribute to the seeming disparity of the estimates. The unexplained or residual variation, σ^2_e, is by far the largest source of variation, about 50% of the total. This result is larger than that reported by Hickman and Henderson (1955) of 40% and lower than the 60–70% reported by Legates *et al.* (1956) for a sire by herd analysis ignoring year-season effects and interactions.

The sampling variances of these estimates are not known except for σ^2_e. The well known expression for the variance of σ^2_e is

$$\frac{2\sigma^4_e}{\text{degrees of freedom}},$$

for example, see Crump (1951) or Searle (1956). Searle (1958) has developed expressions for large-sample sampling variances of the components of variance estimated by Method One of Henderson (1953) for the two-way classification with non-orthogonal data. More recently Searle (1961) has developed similar expressions for the sampling variances of variance components estimated for the two-way nested classification with non-orthogonal data. Extension of the procedure to the three-way classification with unequal subclass numbers has not been accomplished.

The importance of herd, year-season, and

herd by year-season effects is apparent from the results shown in table 2. Consequently, sire evaluation programs should take into account these sources of variation which might influence the evaluation of sires when daughter records are unequally grouped in herds and year-seasons. The method, proposed by Henderson *et al.* (1954) and discussed more completely by Henderson (1956) and Heidhues *et al.* (1961), whereby daughter records are adjusted for contemporary records made in the same herd-year-season, is cited as an example of an attempt to remove these sources of variation. The $\frac{n}{n+l}$ adjustment for the stablemate average which Henderson *et al.* (1954) reported also makes use of herd and error components of variance.

The estimates of variance components in table 2 are of interest in planning progeny testing programs similar to those discussed by Dickerson (1942), Dickerson and Hazel (1944) and Robertson and Rendel (1950). Knowledge of sources of variation also aid in planning animal husbandry experiments, see for example Henderson (1960).

Conclusions

If the three-way classification analysis is appropriate for dairy production records of artificially sired Holstein cows, then approximately 50% of the variation is unaccounted for by sire, herd, year-season, and their two and three-way interaction components of variance.

Variance due to herd effects makes up a large part of the accountable variation, about 30% of the total.

The sire component corresponds to 6–7% of the total variance which agrees with earlier estimates.

The year-season component estimated in this study, 2%, appears to influence the total variance less than other reports have indicated.

The sire by herd and sire by year-season components are very small which indicates there is little genetic by environmental interaction in dairy records under New York conditions.

The herd by year-season interaction seems to make up a significant portion, 6–8%, of the total variation, suggesting that sire testing programs must consider this joint effect.

The variation of first records and second records of AI daughters appeared to be partitioned similarly. Hence, any selection practiced on the basis of first records evidently did not greatly influence the components of variance of second records.

As expected the total variance of fat and milk records is composed of similar percentages of the variance components.

Summary

Components of variance are estimated for the three-way classification analysis of variance of DHIA reported first and second milk and fat records of artificially sired Holstein cows and of Owner-Sampler reported milk and fat records of artificially sired Holstein cows.

The total variance of milk and fat records is partitioned into the following components with the approximate percent of total variance: sire, 6%; year-season, 2%; herd, 30%; sire by year-season, 0%; sire by herd, 1–2%; herd by year-season, 6–8%; sire by herd by year-season, 1–7%; and residual, 50%.

Literature Cited

Baker, M. L., L. N. Hazel and C. F. Reinmiller. 1943. The relative importance of heredity and environment in the growth of pigs at different ages. J. Animal Sci. 2:3.

Bywaters, J. H. 1937. The hereditary and environmental portions of variance in weaning weights of Poland-China pigs. Genetics 22:457.

Crump, S. L. 1951. Present status of variance component analysis. Biometrics 7:1.

Dickerson, G. E. 1942. Experimental design for testing inbred lines of swine. J. Animal Sci. 1:326.

Dickerson, G. E. and L. N. Hazel. 1944. Effectiveness of selection on progeny performance as a supplement to earlier culling in livestock. J. Agr. Res. 69:459.

Eisenhart, C. 1947. The assumptions underlying analysis of variance. Biometrics. 3:1.

Heidhues, T., L. D. VanVleck and C. R. Henderson. 1961. Actual and expected accuracy of sire proofs under the New York system of sampling bulls. Z. Tierz. Zücht. Biol. (In press).

Heizer, E. E., M. C. Hervey, G. R. Barrett and G. W. Brandt. 1938. Nicking in dairy cattle. Proc. Am. Soc. Animal Production. p. 67.

Henderson, C. R. 1953. Estimation of variance and covariance components. Biometrics. 9:226.

Henderson, C. R. 1956. Cornell Research on methods of selecting dairy sires. Proc. New Zealand Soc. Animal Production 16:69.

Henderson, C. R. 1960. "Design and analysis of animal husbandry experiments" in Techniques and Procedures in Animal Production Research, American Society of Animal Production. p. 1.

Henderson, C. R., H. W. Carter and J. T. Godfrey. 1954. Use of the contemporary herd average in appraising progeny tests of dairy bulls. J. Animal Sci. 13:949.

Hickman, C. G. and C. R. Henderson. 1955. Components of the relationship between level of

production and rate of maturity in dairy cattle. J. Dairy Sci. 38:883.
Johnson, L. A., W. Bartlett and L. Copeland. 1940. A study of nicking in Jersey cattle. J. Dairy Sci. 23:709.
Legates, J. E., F. J. Verlinden and J. F. Kendrick. 1956. Sire by herd interaction in production traits in dairy cattle. J. Dairy Sci. 39:1055.
Lush, J. L., H. O. Hetzer and C. C. Culbertson. 1934. Factors affecting birth weights of swine. Genetics 19:329.
Robertson, A. and J. M. Rendel. 1950. The use of progeny testing with artificial insemination in dairy cattle. J. Genetics 50:21.
Searle, S. R. 1956. Matrix methods in components of variance and covariance analysis. Ann. Math. Stat. 27:737.
Searle, S. R. 1958. Sampling variances of estimates of components of variance. Ann. Math. Stat. 29: 167.
Searle, S. R. 1961. Variance components in the two-way nested classification. Ann. Math. Stat. (In press).
Seath, D. M. and J. L. Lush. 1940. "Nicking" in dairy cattle. J. Dairy Sci. 23:103.
Stonaker, H. H. and J. L. Lush. 1942. Heritability of conformation in Poland-China swine as evaluated by scoring. J. Animal Sci. 1:99.

EFFECT OF PHOSPHORUS IN DIFFERENT CHEMICAL FORMS ON *IN VITRO* CELLULOSE DIGESTION BY RUMEN MICROORGANISMS [1]

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PHOSPHORUS has been shown to be essential for maximum cellulose digestion by rumen microorganisms (Burroughs *et al.*, 1951; Hall, 1955; Cheng *et al.*, 1955; Anderson *et al.*, 1956). Both ortho and phytin forms of phosphorus have been shown to enhance rumen microbial activity by Raun *et al.* (1956) and Anderson *et al.* (1956). However, very little is known about the availability of meta and pyro forms of phosphorus to rumen microbes. Experiments by Ammerman *et al.* (1957) with sheep showed that phosphorus in gamma calcium pyrophosphate was almost totally unavailable while that supplied by vitreous calcium metaphosphate appeared to be only 50% as available as was phosphorus from monocalcium phosphate. However, Tillman and Brethour (1958b), using radioactive isotope techniques, found that phosphorus was equally as available in acid sodium pyrophosphate as it was in monosodium phosphate.

The objectives of the present experiments were to determine the effects of monosodium phosphate, vitreous sodium metaphosphate, acid sodium pyrophosphate, and calcium phytate upon *in vitro* cellulose digestion by rumen microorganisms, and to ascertain the relative availability to rumen microorganisms of the phosphorus in the various chemical forms. The phosphorus compounds used in these experiments were aliquots of those used in the experiments by Tillman and Brethour (1958a, b). Therefore the *in vitro* results reported herein might be compared to those obtained with sheep.

Experimental Procedure

The *in vitro* technique employing washed suspensions of rumen microorganisms used in these studies was similar to that described by Cheng *et al.* (1955), and later modified slightly by Anderson *et al.* (1956) for phosphorus studies. Feather meal specially hydrolyzed (Hall, 1955) was added to the phosphorus deficient basal medium described by Anderson *et al.* (1956). Rumen microorganisms were obtained from a fistulated Hereford steer grazed on a bluegrass-orchardgrass-Ladino clover pasture. A mineral mixture containing equal parts of dicalcium phosphate and salt was available *ad libitum*.

All phosphorus sources used were reagent grade compounds. In addition to the test sources, a standard phosphorus source for rumen bacterial studies was used. This standard source consisted of a mixture of sodium and potassium orthophosphates (Anderson *et al.*, 1956). Distilled water solutions or suspensions of the phosphorus compounds were pippetted into 75 ml. fermentation tubes which had previously been rinsed in dilute hydrochloric acid and distilled water to remove any residual phosphorus adhering to the glass.

In separate experiments phosphorus from each of the sources was added to the phosphorus deficient basal medium at the following levels: 0, 20, 40, 60, 70, 80, 90, and 100 mcg. of phosphorus per ml. of medium. Treatments were replicated three times within an experiment and the experiment was repeated twice. After the cellulolytic response curve for each phosphorus source was ascertained in this manner, all sources were compared simultaneously under identical conditions in a second series of three experiments at levels of 0, 20, 40, and 60 mcg. of phosphorus per ml. of basal medium. Cellulose remaining at the end of the fermentation period was determined by a slight modification of the method of Crampton and Maynard (1938). The data were treated by analysis of variance and by the multiple range test of Duncan (1955).

Results and Discussion

Rumen microbial cellulolytic response to various levels of each of the sources of phosphorus studied is shown in table 1. Since a single source of phosphorus was studied in the same series of experiments, only data within columns in this table should be compared.

The addition of 20 mcg. of phosphorus

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TABLE 1. CELLULOLYTIC RESPONSE BY RUMEN MICROORGANISMS TO ADDITIONS OF PHOSPHORUS FROM ORTHO-, PYRO-, AND PHYTIN PHOSPHATES

Amount of phosphorus added	Source of phosphorus				
	Calcium phytate	Vitreous sodium metaphosphate	Sodium and potassium phosphate standard	Monosodium orthophosphate	Acid sodium pyrophosphate
mcg./ml. of medium	Cellulose digested, %[a]				
0	22.1	42.8	57.6	19.7	19.8
20	46.8	77.0[b]	71.5	48.1	46.1[b]
40	49.6	89.1	73.2	48.4	60.0
60	50.5	88.4	71.2	47.0	61.6
70	54.6	89.7	73.4	53.6	59.4
80	55.4	90.2	75.6	53.3	62.8
90	54.5	89.8	74.5	54.0	65.6
100	54.4	90.7	70.1	51.4	69.8

[a] Each value is an average of six observations. The mean for group where phosphorus was not added differs significantly ($P<.05$) from each other value in the same column.
[b] Differs significantly ($P<.05$) from all other values in same column.

per ml. of medium from each of the sources resulted in marked ($P<.05$) increases in cellulose digestion by the rumen bacteria. Higher levels of phosphorus (40 mcg. per ml. and above) of vitreous sodium metaphosphate and acid sodium pyrophosphate resulted in additional increases ($P<.05$) in cellulose digestion. Levels of phosphorus above 20 mcg. per ml. from the other sources resulted in slight but statistically insignificant increases in microbial activity as measured by cellulose disappearance. Based on the increased microbial activity that occurred when phosphorus was added to the medium, it would appear that all the sources of phosphorus studied supplied the bacteria with a usable form of phosphorus. The data also show that maximum *in vitro* microbial cellulose digestion occurred when an available form of phosphorus was added to the medium at levels ranging from 20 to 60 mcg. per ml. of medium. This agrees with the results reported by Anderson *et al.* (1956).

The relative availability of the sources of phosphorus based on cellulolytic response by the bacteria is shown in table 2. These data were obtained by assaying all of the sources of phosphorus at levels of 0, 20, 40, and 60 mcg. per ml. of medium in the same experiment. Thus both levels and sources of phosphorus can be compared.

In this series of experiments, phosphorus additions from all of the sources studied again resulted in significant ($P<.05$) increases in cellulose digestion. When all sources are compared at the 20 mcg. per ml. level, it will be noted that 42.8% of the cellulose was digested in fermentation tubes with calcium phytate, whereas 49.5—55.2% of the cellulose was digested in tubes with the same amount of phosphorus from the other sources. These differences are statistically significant ($P<$

TABLE 2. RELATIVE AVAILABILITY OF PHOSPHORUS IN DIFFERENT CHEMICAL FORMS TO RUMEN MICROORGANISMS BASED ON CELLULOLYTIC RESPONSE

Amount of phosphorus added	Source of phosphorus				
	Calcium phytate	Vitreous sodium metaphosphate	Sodium and potassium phosphate standard	Monosodium orthophosphate	Acid sodium pyrophosphate
mcg./ml. of medium	Cellulose digested, %[a]				
0	29.3	29.3	29.3	29.3	29.3
20	42.8	49.5	53.8	51.5	55.2
40	52.8	56.7	56.5	58.2	61.3
60	57.2	56.0	59.0	57.6	59.5

[a] Each value is an average of six observations. The means of any sources not underscored by the same line are significantly different ($P<.05$).

.05) and indicate that calcium phytate phosphorus was slightly less available to the bacteria as assayed in these experiments than was the phosphorus from the other sources. Rumen microbial breakdown of cellulose was also significantly lower ($P<.05$) in tubes with 40 mcg. per ml. of calcium phytate phosphorus than in tubes with the same amount of phosphorus from acid sodium pyrophosphate. However, at the 60 mcg. per ml. level, all sources of phosphorus produced about the same cellulolytic response by the rumen microbes.

As has been stated, the availability of the phosphorus in the sources studied in these experiments had been previously determined with sheep by Tillman and Brethour (1958a, b). The results reported herein with rumen microbes pertaining to calcium phytate, monosodium orthophosphate, and acid sodium pyrophosphate agree very well with those of the above workers who, using radioisotope techniques, found these particular forms of phosphorus to be equally available sources of phosphorus for sheep. However, whereas vitreous sodium metaphosphate was found to increase *in vitro* cellulose digestion by rumen bacteria in the present experiments, this same source of phosphorus was found to be a poor source of phosphorus for sheep. The above workers found sodium metaphosphate to be absorbed from the gastrointestinal tract of sheep equally as well as were the other sources of phosphorus but significantly more endogenous phosphorus appeared in the feces of sheep fed this chemical form of phosphorus. Ammerman *et al.* (1957) have previously reported results showing vitreous calcium metaphosphate to be a poor source of phosphorus for sheep.

Based on the work reported above and the results of the experiments reported herein, it would appear that a phosphorus source which increases *in vitro* rumen microbial breakdown of cellulose may not necessarily be a usable source of phosphorus for the animal body proper. Although the availability of phosphorus to rumen bacteria *per se* is very important, these results indicate that the rumen microbial assay technique may not be adequate to fully assess the overall availability of all phosphorus sources for ruminant animals. Additional experiments to further clarify this point will be reported in a subsequent publication.

Summary

Washed suspensions of rumen microorganisms were used in a series of studies to determine the effects of adding various levels of phosphorus in different chemical forms upon cellulose digestion. Monosodium orthophosphate, vitreous sodium metaphosphate, acid sodium pyrophosphate, and calcium phytate were the sources of phosphorus used. Marked increases ($P<.05$) in cellulose digestion occurred when levels of 20 to 100 mcg. of phosphorus per ml. of medium from each source were added. Phosphorus in all of the chemical forms studied appeared to be utilized by rumen bacteria.

Results of experiments in which all of the chemical forms of phosphorus were assayed simultaneously showed that slight but significant differences in cellulose digestion occurred when all sources were added at levels to supply 20 and 40 mcg. of phosphorus per ml. of basal medium. However, all sources of phosphorus produced about the same microbial cellulolytic response when 60 mcg. of phosphorus per ml. of medium from each source were added. The relationship of the *in vitro* results to results of availability studies of these same phosphorus sources with sheep was discussed.

Literature Cited

Ammerman, C. B., R. M. Forbes, U. S. Garrigus, A. L. Neumann, H. W. Norton and E. E. Hatfield. 1957. Ruminant utilization of inorganic phosphates. J. Animal Sci. 16:796.

Anderson, Russell, Edmund Cheng and Wise Burroughs. 1956. A laboratory technique for measuring phosphorus availability of feed supplements fed to ruminants. J. Animal Sci. 15:489.

Burroughs, W., A. Latone, P. De Paul, P. Gerlaugh and R. M. Bethke. 1951. Mineral influences upon urea utilization and cellulose digestion by rumen microorganisms using the artificial rumen technique. J. Animal Sci. 10:693.

Cheng, E. W., Glen Hall and Wise Burroughs. 1955. A method for the study of cellulose digestion by washed suspensions of rumen microorganisms. J. Dairy Sci. 38:1225.

Crampton, E. W. and L. A. Maynard. 1938. The relation of cellulose and lignin content to the nutritive value of animal feeds. J. Nutr. 15:383.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics 11:1.

Hall, O. Glen. 1955. Unidentified factors stimulatory to cellulose digestion by rumen microorganisms. Ph.D. Thesis. Iowa State University, Ames, Iowa.

Raun, Arthur, E. W. Cheng and Wise Burroughs. 1956. Phytate phosphorus hydrolysis and availability to rumen microorganisms. J. Agr. and Food Chem. 4:869.

Tillman, Allen D. and J. R. Brethour. 1958a. Utilization of phytin phosphorus by sheep. J. Animal Sci. 17:104.

Tillman, Allen D. and J. R. Brethour. 1958b. Ruminant utilization of sodium meta-, ortho- and pyrophosphates. J. Animal Sci. 17:792.

PROTEIN-ENERGY RELATIONSHIPS IN THE RATIONS OF EARLY WEANED PIGS

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CONTINUED interest in the early weaning of baby pigs has stimulated research on the nutrient requirements of the pig during early life. Recognition of the principle that maintaining an optimum ratio of protein to energy is necessary for the formulation of efficient rations, suggests a need for a definition of the protein-energy requirements of the baby pig.

Several reports have appeared relative to the protein requirements of the pig at this stage of growth. Sewell *et al.* (1953) reported satisfactory growth with suckling pigs fed simulated milk diets containing 24% and 28% protein. Becker *et al.* (1954) obtained maximum performance with pigs from 3 to 28 days of age on diets containing 22.4% milk protein whereas 12% protein produced maximum performance with pigs from 5 to 9 weeks of age. Peo *et al.* (1957), studying four levels of protein and four variations of fat level, reported peak performance at the 20% protein level with no significant effect of fat level on gains. More recently, Rutledge *et al.* (1961) reported that 20% protein was required for maximum nitrogen retention, while Lloyd and Crampton (1961) concluded that 24% protein is required in early-weaning rations for maximum performance.

The experiments reported herein were conducted to study the effects of variations in protein content as affected by caloric density of rations for pigs weaned at three weeks of age.

Procedure

Experiment I. Forty-two purebred Landrace pigs, weaned at 3 weeks of age, were used in this experiment. The pigs were blocked on the basis of litter into six groups of seven pigs each. The groups were then randomly allotted to treatment. An experimental plan was employed using a 2 x 3 factorial experiment with two levels of fat at three levels of protein. A fortified corn-soybean oil meal basal ration, as shown in table 1 (Ration A), was used in this trial. In order to obtain protein levels of 10, 15 and 20%, the corn-soybean oil meal ratio was varied. Variations in energy density of the rations were obtained by altering dietary fat level. Corn oil was used as a source of fat and where it was added to the ration, it replaced cerelose by weight. Thus, the amino acid balance of the ration was the same at any given level of protein irrespective of energy level, since the corn-soybean oil meal ratio was not altered between levels of energy. Levels of fat added to the rations were 0 and 8%.

The pigs were housed in a pig nursery building designed to provide a comfortable environment for pigs of this age. Free access to the feed and fresh drinking water was provided the pigs at all times. The experiment was conducted over a 5-week period.

Experiment II. A 2 x 3 factorial experiment, using the same general plan as that employed in Experiment I was used. However, a purified basal ration was employed in this trial as shown in table 1 (Ration B).

Variations in protein levels were obtained by increasing the level of isolated soybean protein at the expense of the carbohydrate portion of the ration. Protein levels of 10, 15 and 20% were studied at two levels of fat, 2 and 10%. Corn oil was used as a source of fat.

Purebred Landrace pigs weaned at 3 weeks of age were allotted to 12 groups of six pigs each on the basis of litter, weight and sex. The groups were then randomly allotted in replicate to each of the six treatments. All pigs were housed and managed as indicated previously. The pigs were fed a prestarter ration for 1 week prior to the allotment to this experiment in order to accustom the newly weaned pigs to the consumption of a dry ration. The experiment was conducted for a four week period.

Experiment III. Twenty Duroc and Poland

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TABLE 1. COMPOSITION OF BASAL RATIONS

Ration A		Ration B	
Ingredient	%	Ingredient	%
Soybean oil meal (50%)	19.00	ADM protein	18.34
dl-Methionine	0.02	dl-Methionine	0.26
Corn	63.18	Corn starch	48.84
Cerelose	15.00	Cereiose	24.00
Mineral premix	2.00 [a]	Corn oil	2.00
Vitamin-antibiotic premix	0.80 [b]	Solka floc	3.00
		Mineral premix	3.27 [c]
		Vitamin-antibiotic Corn oil	0
Crude protein % (NX6.25)	15.00	premix	0.29 [d]
			15.00

[a] Supplied following per 100 lb. of feed: defluorinated phosphate, 1.0 lb.; limestone, 0.5 lb.; and trace mineral-high zinc salt, 0.5 lb.

[b] Supplied the following quantities per lb. of feed: riboflavin, 4.0 mg.; pantothenic acid, 8 mg.; niacin, 18 mg.; choline, 180 mg.; Vitamin B_{12}, 20 mcg.; Vitamin A, 1500 IU; Vitamin D_3, 600 IU; chlortetracycline, 20 mg.; and streptomycin sulfate, 20 mg.

[c] Supplied the following quantities per 100 lb. of feed: defluorinated phosphate, 2.1 lb.; NaCl, 0.3 lb.; K_2HPO_4, 202.0 gm.; KCl, 86.35 gm.; $MgCO_3$, 69.40 gm.; $FeSO_4 \cdot 7H_2O$, 24.90 gm.; $MnSO_4 \cdot H_2O$, 6.15 gm.; $CoCl_2$, 1.21 gm.; $CuSO_4$, 0.25 gm.; $ZnCO_3$, 2.30 gm.; KI, 0.14 gm.

[d] Supplied the following quantities per lb. of feed: Vitamin A, 3,000 IU; Vitamin D_3, 800 IU; Alpha tocopherol acetate, 10 IU; menadione, 2 mg.; ascorbic acid, 25 mg.; thiamine, 2.5 mg.; riboflavin, 5 mg.; calcium pantothenate, 10 mg.; niacin, 30 mg.; choline chloride, 500 mg.; p-aminobenzoic acid, 8 mg.; inositol, 90 mg.; biotin, 30 mcg.; pyridoxine, 2.5 mg.; folic acid, 200 mcg.; Vitamin B_{12}, 20 mcg.; streptomycin sulfate, 20 mg.; and chlortetracycline, 20 mg. An antioxidant (Santoquin) was added at a level of 0.0125% of the feed.

China pigs were used in a 2 x 2 factorial experiment in which the factors were levels of fat and variations in calorie-protein ratio. The purified diet shown in table 1 (Ration B) served as the basal ration. Formulations were made by manipulating the protein, carbohydrate, fat and fiber portions of the ration so as to obtain four rations with isocaloric productive energy values, but which contained two variations in calorie-protein ratios and two levels of fat. Calorie-protein ratios of 70:1 and 51:1 were used with fat levels of 2 and 12%. The pigs were housed and managed as described previously, with the exception that the pigs were placed on the experimental rations immediately after removal from the sow. Duration of the experiment was 28 days.

TABLE 2. ANALYSIS OF VARIANCE

	Experiment I		Experiment II	
Source of variation	d.f.	Mean square	d.f.	Mean square
Total	40	.....	71	.....
Replication	..	.....	1	.6142**
Litter	5	.0290	..	.....
Treatment	5	.5113**	5	.4211**
Fat	1	.0120	1	.0861
Protein	2	1.2548**	2	.9382*
Linear	1	2.0520**	..	.....
Quadratic	1	.4576**	..	.....
Protein x fat	2	.0175	2	.0716
Linear	1	.0304	..	.....
Quadratic	1	.0047	..	.....
Litter x treatment	25	.0208*	..	.....
Replication x treatment	..	.....	5	.0071
Error	15	.0073	60	.0289

* $P < .05$.
** $P < .01$.

Results and Discussion

A highly significant difference due to treatment was found in Experiment I (table 2). A summary of the data is presented in table 3. The protein linear component of variation accounted for 61.6% of the total variation. Pigs receiving 10% protein at both levels of fat intake gained poorly. Increasing the dietary protein to a level of 15% produced a marked response in rapidity of gains at both fat levels fed. Further increasing the protein content of the diet to 20% resulted in a moderate increase in rate of gain at the higher fat level, but failed to increase growth rate at the lower level of fat. The most rapid and efficient gains were obtained with the combination of 20% protein and 8% added fat. Addition of fat to the ration failed to stimulate a growth response at the 10 and 15% protein levels.

There was a progressive decrease in the quantity of feed required to produce a unit of gain as the protein level was increased in Experiment I. Only slight improvement in the efficiency of feed utilization was obtained at any given protein level through the addition of fat.

Results of Experiment II are summarized

TABLE 3. SUMMARY OF AVERAGE PERFORMANCE DATA OF PIGS ON EXPERIMENT I

	10% Protein		15% Protein		20% Protein	
	0% Fat	8% Fat	0% Fat	8% Fat	0% Fat	8% Fat
Ration no.	1	2	3	4	5	6
Number of pigs	7	7	7[a]	7	7	7
Ave. initial weight, lb.	11.5	11.5	11.4	11.2	11.4	11.7
Ave. final weight, lb.	21.7	21.1	42.4	39.1	40.1	45.3
Ave. daily gain, lb.	0.29	0.28	0.78	0.80	0.82	0.96
Feed per lb. of gain, lb.	4.14	4.10	2.13	2.10	1.86	1.81

[a] One pig died of undetermined cause the third day on experiment. Value calculated by the missing plot technique.

in table 4. A highly significant difference due to protein level was found with the protein component accounting for much of the total variation (table 2). Pigs receiving the 10% protein rations gained more slowly than pigs receiving either 15% or 20% protein at each level of fat employed.

At the 2% level of dietary fat, there was a positive response in rate of gain with each increase in protein level fed. However, when the caloric density of the ration was increased by adding fat, a positive response was obtained only when the protein level was increased from 10% to 15%, while a slight decrease in rate of gain resulted when the protein level was raised to 20%. While the reason for this slight decrease is not clear, the possibility that a dietary component other than protein may have exerted a limiting effect in this instance cannot be eliminated.

protein on Experiment I was found as compared to the pigs receiving the same protein levels on Experiment II. It may be observed that the difference in gains between pigs on the two experiments was more pronounced on the higher fat rations at the 10% protein level. A corresponding marked improvement in feed efficiency was also obtained with pigs on the purified diet at the 10% protein level. A similar trend in the results between the two experiments at the 15% protein level may be observed, although not nearly so pronounced as at the 10% level.

A large part of this difference is apparently explained on the basis of a more adequate balance of amino acids being supplied to meet the pig's requirement in the purified ration as compared to the corn-soybean meal type ration at the 10% protein level.

There was a considerable increase in rate

TABLE 4. SUMMARY OF AVERAGE PERFORMANCE DATA OF PIGS ON EXPERIMENT II

	10% Protein		15% Protein		20% Protein	
	2% Fat	10% Fat	2% Fat	10% Fat	2% Fat	10% Fat
Ration no.	1	2	3	4	5	6
Number of pigs	12	12	12	12	12	12
Ave. initial weight, lb.	13.3	13.8	12.9	13.7	13.1	13.3
Ave. final weight, lb.	28.4	34.0	38.9	41.7	41.1	40.3
Ave. daily gain, lb.	0.54	0.72	0.93	1.00	1.00	0.96
Feed per lb. of gain, lb.	2.69	2.31	2.04	1.91	1.88	1.78

However, the increased efficiency of feed utilization obtained on the 20% protein, high-fat ration would tend to eliminate this hypothesis.

There was a marked increase in daily gains when the fat level was increased from 2% to 10% in the rations containing 10% protein. A corresponding increase in efficiency of feed utilization was also obtained. A similar trend resulted from varying the fat levels at the 15% protein concentration. Increasing the fat content of the 20% protein rations resulted in a slight improvement in efficiency of feed utilization, although there was no increase in growth rate.

The amount of feed required to produce a unit of gain was progressively decreased as the level of protein was increased in Experiment II. There was also an increase in efficiency of feed utilization with increasing fat level at any given protein concentration.

A striking contrast in the growth rate of pigs receiving the rations containing 10% of gain with a corresponding improvement in feed utilization attributable to the increased energy density at the 10% protein level in Experiment II. In contrast, no difference in performance between the two energy levels occurred at the 10% protein level on Experiment I. Thus, it appears that a more efficient utilization of dietary protein occurred at the higher energy level where the source of protein was of good quality. Support for such a view may be drawn from the studies of Munro and Naismith (1953) and Sibbald *et al.* (1956) in which they observed that increments in energy supply resulted in a linear improvement in nitrogen retention in rats. These authors also produced evidence that there is an optimum available energy level for each protein level of a diet at which maximum nitrogen retention is obtained. Lowrey *et al.* (1958) and Asplund *et al.* (1960) have reported increased apparent digestibility of protein resulting from the addition of fat to baby pig rations.

Calculation of the calorie-protein ratios of the various rations employed in Experiments I and II were made, using the productive energy values as reported by Fraps (1943). A study of these ratios in conjunction with the growth rate and feed efficiency of the pigs receiving the various rations indicates that maximum performance was obtained on those rations containing ratios of 50:1 to 55:1, although good performance was also obtained at ratios of 70:1 and 80:1 in Experiment II.

Results of Experiment III are reported in table 5. No significant differences in growth rate were obtained between the fat levels fed. Pigs grew equally as well on the ration containing a calorie-protein ratio of 70:1 as those receiving the ration containing a calorie-protein ratio of 51:1. However, there was an apparent improvement in the efficiency of feed utilization with those pigs receiving the 51:1 calorie-protein ratio.

TABLE 5. SUMMARY OF AVERAGE PERFORMANCE DATA OF PIGS ON EXPERIMENT III

	C/P[a] ratio 70:1		C/P[a] ratio: 51:1	
	2% Fat	12% Fat	2% Fat	12% Fat
Ration no.	1	2	3	4
Number of pigs	5	5	5	5
Av. initial wt., lb.	10.8	11.3	10.8	11.1
Av. final wt., lb.	28.2	29.2	29.2	27.8
Av. daily gain, lb.	0.62	0.64	0.66	0.60
Feed per lb. of gain, lb.	2.47	2.30	2.09	2.16

[a] Calorie-protein ratios calculated from productive energy values (Fraps, 1943).

Summary

Three experiments involving 134 pigs weaned at 3 weeks of age were conducted to study protein-energy relationships. A corn-soybean oil meal ration was employed in Experiment I, while a ration composed of purified ingredients was used in Experiments II and III. A marked increase in growth rate was obtained when the protein level was increased from 10% to 15% in Experiments I and II. Further increasing the protein content of the ration to 20% resulted in slightly faster gains in Experiment I, but not in Experiment II. A linear decrease in the quantity of feed required to produce a unit of gain was obtained as the protein level of the rations was progressively increased. Increasing the energy density of the ration by the addition of corn oil resulted in an increase in rate of gain with a corresponding improvement in efficiency of feed utilization at both the 10% and 15% protein levels on the purified ration. Under the conditions imposed in Experiments I and II, it appears that a calorie-protein ratio, expressed as productive energy of between 50:1 to 55:1, produced maximum performance. Isocaloric rations containing c/p ratios of 70:1 and 51:1 in Experiment III produced no difference in growth rate although the 51:1 ratio resulted in an apparent improvement in feed efficiency.

Literature Cited

Asplund, J. M., R. H. Grummer and P. H. Phillips. 1960. Stabilized white grease and corn oil in the diet of baby pigs. J. Animal Sci. 19:709.

Becker, D. E., D. E. Ullrey and S. W. Terrill. 1954. Protein and amino acid intakes for optimum growth rate in the young pig. J. Animal Sci. 13:346.

Fraps, G. S. 1943. Relation of the protein, fat and energy of the ration to the composition of chickens. Poul. Sci. 22:421.

Lloyd, L. E. and E. W. Crampton. 1961. Effect of protein level, amino acid supplementation and duration of feeding of a dry early-weaning pig ration. J. Animal Sci. 20:172.

Lowrey, R. S., W. G. Pond and J. H. Maner. 1958. The effect of calorie-protein ratio on digestibility, feed efficiency and weight gain in growing swine. J. Animal Sci. 17:1165 (Abstr.).

Munro, H. N. and D. J. Naismith. 1953. The influence of energy intake on protein metabolism. Biochem. J. 54:191.

Peo, E. R., Jr., G. C. Ashton, V. C. Speer and D. V. Catron. 1957. Protein and fat requirements of baby pigs. J. Animal Sci. 16:885.

Rutledge, E. A., L. E. Hanson and R. J. Meade. 1961. Protein requirements of suckling age pigs. J. Animal Sci. 20:142.

Sewell, R. F., B. E. Sheffy, R. G. Eggert and J. K. Loosli. 1953. Studies on the protein requirements of suckling pigs. J. Animal Sci. 12:597.

Sibbald, L. R., R. T. Berg and J. P. Bowland. 1956. Digestibile energy in relation to food intake and nitrogen retention in the weanling rat. J. Nutr. 59:385.

DDT RESIDUES IN THE INTERNAL FAT OF BEEF CATTLE FED CONTAMINATED APPLE POMACE

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APPLE pomace is that by-product of the processing industry which remains after cider has been expressed from small whole apples, and the stems, cores and peelings remaining after preparation of apple juice and sauce for human consumption. A recent report (Burris and Priode, 1957) stated that apple pomace could partially replace certain roughages used for wintering beef cows, thereby providing substantial savings to cattlemen and apple-processors, alike. Because marketed apples frequently contain DDT spray residues at or near the legal tolerance of 7 ppm, the DDT content of the subsequent pomace, by virtue of its concentration on peelings, often greatly exceeds 7 ppm. No gross toxic effects were observed in the cattle studied by Burris and Priode (1957).

At the Beef Cattle Research Station, Front Royal, Virginia, during the winter of 1957–58, there were, however, three unexplained deaths (in the absence of any visible toxicity) among 140 heifer calves which received wet apple pomace for 126 days following weaning. Fat samples obtained following slaughter of an apparently healthy heifer from this group contained DDT residues exceeding 47 ppm. These findings prompted the present inquiry regarding the internal accumulation of DDT residues by cattle receiving contaminated pomace, and the subsequent dissipation of these residues when receiving a DDT-free ration.

Materials and Methods

Six crossbred heifers, which averaged 11 months of age at the beginning of the experiment, were group-fed and given free access to dried apple pomace which contained 103 ppm DDT. In addition they received 4 lb. mixed hay and 1 lb. cottonseed meal per head per day. This ration was offered for 104 days, after which no pomace was fed. The feeding of contaminated pomace began January 26, 1959; it was discontinued on May 10, 1959. All heifers were slaughtered on or before January 6, 1961.

Claborn (1956) stated that the chlorinated hydrocarbon insecticides such as DDT are fat-soluble, and when absorbed via spraying, ingestion, or both, they tend to be stored in the fatty tissue. Biopsies of the omentum were obtained from all animals 49 days before pomace feeding began. The six heifers were then randomly assigned to two groups of three heifers, each. Successive biopsies were obtained thereafter from alternate groups. As a result, five fat samples were obtained from each heifer, the interval between consecutive samples from each animal being 180 ± 67 days. Surgical technique was that described by Radeleff (1950). DDT content of each fat sample was determined by the colorimetric method described by Schechter *et al.* (1945).

Results and Discussion

Average consumption of dried apple pomace was 8.7 lb. per head per day during the period it was offered. The data shown in table 1 indicate a rapid internal accumulation of DDT residue following ingestion of contaminated feed. None of the symptoms of DDT poisoning described by Radeleff *et al.* (1955) was observed during the experiment. Average residues of 75.7 ppm DDT were detected in fat samples taken 79 days after pomace feeding began. It is presumed that some additional residue was deposited during the 25 days of pomace feeding which followed this observation, but no fat samples were obtained until 80 days after pomace feeding ceased. Claborn (1956) reported internal residues of DDT which

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[5] Apple pomace was donated by National Fruit Product Company, Winchester, Virginia.

TABLE 1. OBSERVED DDT RESIDUE (ppm) IN INTERNAL FAT OF 6 YEARLING HEIFERS FED CONTAMINATED DRIED POMACE FOR 104 DAYS[a]

Interval, days[b]	Animal number					
	8701	8705	8710	8702	8706	8818
Pre-feeding	3.5	4.2	3.8	4.4	4.0	3.3
23	36.0	61.0	51.0	....	....	....
79	....	....	....	67.0	87.0	73.0
184	35.0	61.0	53.0	....	....	....
274	....	....	....	29.0	42.0	26.0
360	13.6	16.6	17.0	....	....	....
463	....	....	....	8.5	13.5	9.5
560	....	8.5	....	....	....	....
613	....	....	7.8	....	....	....
711	7.3	....	....	7.2	13.0	8.1

[a] Results shown have not been corrected for apparent DDT in control samples since no controls were available.
[b] From time feeding started until sampling.

reached 42 ppm after feeding four cattle a ration containing 25 ppm DDT for 12 weeks. Twenty-four weeks after removal of DDT from the ration of the cattle described by Claborn, residues of DDT in the internal fat were 5.7 ppm. Claborn also found residues of 88 ppm in six calves after they had been sprayed 28 times at bi-weekly intervals, but no toxic effects were reported. Results of the present investigation, supported by those of Claborn (1956), indicate that internal residues of DDT well in excess of those observed herein may be required before toxic effects are manifest in cattle of this age.

Data dealing with the dissipation of DDT residue following cessation of pomace feeding were fitted to the exponential, $Y=aX^b$. Transformation of observed values for X (number of days elapsed since receiving pomace) and Y (DDT residue) to logarithms rectified the data as indicated by the reduction in error variance attributable to linear regression (table 2), the within animal correlation of $-.97$ for Y and X, and the linear trend of the data shown in figure 1. Regression of the logarithm of DDT residue on the logarithm of days elapsed was $-.98\pm.07$, an absolute value sufficiently close to unity to suggest that an inverse relationship exists between Y and X such that their product is nearly constant, at least over the observed range of these data. In this study DDT residue was dissipated most rapidly immediately after pomace feeding was stopped, the absolute rate progressively decreasing thereafter. At X= 635 days, the estimated DDT residue was 7.0 ± 1.2 ppm.

TABLE 2. VARIATION IN LOGARITHMS OF DDT RESIDUE FOLLOWING REMOVAL OF CONTAMINATED POMACE FROM RATION

Source	df	Mean square
Among animals	5	0.1608
Within animals	12	0.6660
Regression due to time	1	7.5274
Deviations from regression	11	0.0422

Nearly 2 years after the present experiment was begun, residues had not receded to the value of 3.9 ppm observed initially, although the animals were not sprayed with DDT during this time. The small DDT residue found before the experiment began is believed attributable to previous spraying of the experimental animals as calves, to the calves' ingestion of their dams' milk contaminated by previous spraying, or both. Claborn (1956) reported DDT residues of 15 ppm in the internal fat of eight lactating beef cows sprayed 28 days earlier with DDT. In the same study, internal fat of four calves which were sprayed at the same time as their dams contained 52 ppm DDT, whereas that of four calves which were not sprayed, and whose absorption of DDT was primarily from ingestion of their dams' contaminated milk, was 25 ppm. Results of Claborn, together with those of the present study, suggest that: (1) DDT residues absorbed via ingestion are accumulated more rapidly, or dissipated more slowly than those absorbed via spraying, or both, and (2) there are large differences between calves and mature cattle in rates of accumulation and subsequent dissipation of DDT residues, whether acquired via spraying, ingestion, or both.

Affinity of DDT for fat, rather than for muscle, was indicated by finding residues of 1.0 ppm at the time of slaughter in a sample of lean meat from a heifer whose fat contained 8.5 ppm.

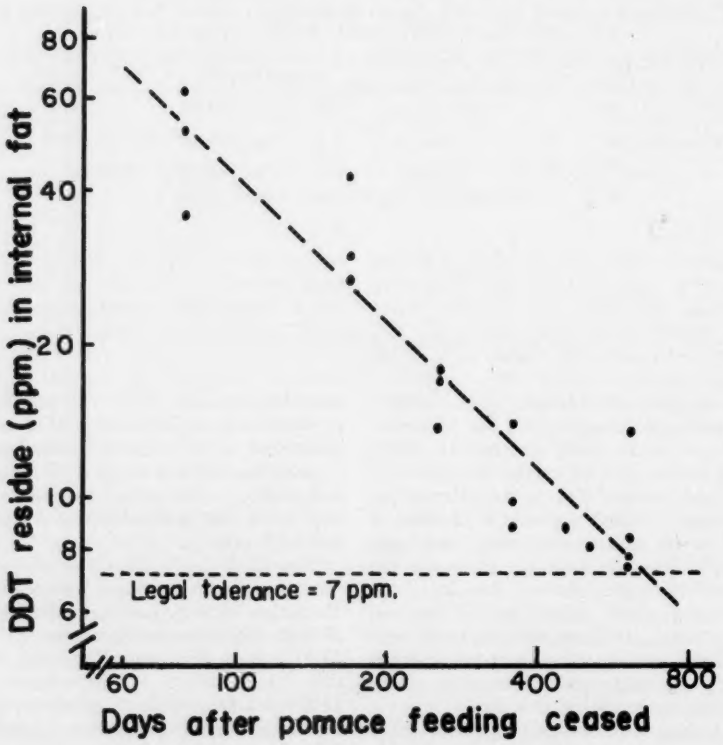

Figure 1. Observed and predicted dissipation of internal DDT residue.

Summary

Six yearling heifers were fed dried apple pomace known to be contaminated with 103 ppm DDT. Samples of internal fat were taken from each animal before, during, and following the apple pomace feeding period of 104 days. A 10-fold excess of the permissible legal tolerance of DDT (7 ppm) accumulated internally with no visible manifestation of toxicity to the cattle. Excessive residues thus attained are slowly dissipated, average residues being 8.6 ppm when the cattle were slaughtered 566 days after last receiving pomace.

Literature Cited

Burris, M. J. and B. M. Priode. 1957. The value of apple pomace as a roughage for wintering beef cattle. Va. Agr. Exp. Sta. Res. Rpt. No. 12.

Claborn, H. V. 1956. Insecticide residues in meat and milk. U.S.D.A. ARS-33-25.

Radeleff, R. D. 1950. Omentectomy of cattle for studying insecticide residue in the body. Vet. Med. 45:125.

Radeleff, R. D., G. T. Woodard, W. J. Nickerson and R. C. Bushland. 1955. The acute toxicity of chlorinated hydrocarbon and organic phosphorus insecticides to livestock. U.S.D.A. Tech. Bul. 1122.

Schechter, M. S., S. B. Soloway, R. A. Hayes and H. L. Haller. 1945. Ind. & Eng. Chem., Anal. Ed., 17, 704.

EFFECT OF HUMAN CHORIONIC GONADOTROPHIN ON MAINTENANCE OF THE CORPUS LUTEUM AND EMBRYONIC SURVIVAL IN THE COW

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GREENSTEIN *et al.* (1958), Loy *et al.* (1960) and Wiltbank *et al.* (1961) have shown that injection of estrogen in the cow induced early regression of the corpus luteum. In addition, the last workers found that injection of gonadotrophins, following injection of estrogen, prevents early regression of the corpus luteum. They postulated that the regression of the corpus luteum induced by estrogen was the result of a deficiency of gonadotrophin, probably LH. Gonadotrophins have been implicated also in the maintenance of the corpus luteum in other species. The administration of human chorionic gonadotrophin (HCG) prolonged the life of the corpus luteum in the rat (Katzman, *et al.* 1931), the monkey (Hisaw, 1944) and the human (Bradbury, *et al.* 1950). It seemed important, therefore, to determine if the life of the corpus luteum in the cow could be prolonged by injection of luteinizing hormone.

The purpose of the experiment reported here was to determine the effect of daily injections of human chorionic gonadotrophin (HCG) on the maintenance of the corpus luteum and on embryonic survival in the cow.

Materials and Methods

Five Hereford heifers, having a previous estrous cycle between 17 and 24 days in length were used in the first experiment conducted in the summer of 1960. Each heifer received daily intramuscular injections of 1,000 I.U. of human chorionic gonadotrophin (HCG) [8] from the 15th day to the 26th day (day of estrus was considered day 1 of the cycle). Reproductive organs of the heifers were examined, per rectum, on the day of injection and alternate days thereafter until estrus occurred. Checks for estrus were made twice daily using a sterilized bull.

Eighty-two Hereford heifers were used in the second experiment which was conducted in the fall of 1960. Heifers were hand mated at random to one of seven bulls. They were allotted to the treated or control group on the basis of the bull to which they were bred and the date of breeding. Treated animals received daily intramuscular injections of 1,000 I.U. of HCG from the 15th day to the 35th day (day of breeding was day 1). Checks for estrus were made using a sterilized bull painted on the brisket with pigmented grease. The reproductive organs of all heifers were examined per rectum on the 15th day and three additional times on the day which fell closest to the 17th, 21st and 28th day. Examinations were conducted thrice weekly. Pregnancy diagnoses were made on the 36th day and between the 77th and 85th day of pregnancy. Reproductive organs were examined following slaughter between 134 and 194 days after breeding.

Results

Administration of HCG prolonged the estrous cycle and caused maintenance of the corpus luteum in cycling heifers. The estrous cycle of the treated heifers averaged 32.4 days (range 27 to 42 days), while the estrous cycle of the control heifers averaged 17.7 days (range 17 to 19 days). The corpus luteum was maintained in four of the five heifers until injections ceased on the 26th day.

Daily injection of bred heifers with 1,000 I.U. of HCG caused maintenance of the corpus luteum in heifers which were subsequently diagnosed open, but did not signifi-

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[8] Follutein (E. R. Squibb and Sons.)

TABLE 1. EFFECT OF CHORIONIC GONADOTROPHIN ON CONCEPTION RATE AND MAINTENANCE OF THE CORPUS LUTEUM IN BRED HEIFERS

Group	No. bred[a]	Pregnant 36th day	Open heifers	Open heifers in which corpus luteum had regressed by			
				17th day	21st day	28th day	36th day
		%	No.				
Treated	39	69	12	....	1 (8)	3 (25)	8 (67)
Control	41	63	15	1 (8)[b]	8 (53)	12 (80)	14 (93)

[a] Does not include two bred heifers assigned to the treated group. One heifer had a 10-day estrous cycle and another had no palpable corpus luteum at the time injection was to start.
[b] Numbers in parentheses are percents.

cantly increase the conception rate (table 1).

Ovarian activity was increased in heifers treated with HCG. Accessory corpora lutea were formed in 67% of the heifers diagnosed pregnant as compared to 42% for bred heifers found open and in none of the cycling heifers (table 2). One accessory corpus luteum was found in each of 20 heifers and two in each of three heifers. The greatest formation of accessory corpora lutea occurred between the 21st and 28th day in pregnant heifers, but the distribution was about equal at all stages in the bred heifers which were found open. Accessory corpora lutea were still present in the ovaries at the time of slaughter.

The number of heifers with palpable follicles and the size of the follicles were increased by treatment with chorionic gonadotrophin. The amount of follicular development was approximately the same in all treated groups.

The number of heifers which were diagnosed pregnant 35 days after breeding but which were open at subsequent palpation or at slaughter did not differ significantly for the two groups (table 3).

Discussion

Results show that the corpus luteum can be maintained in the cow past the normal time of regression by injection of chorionic gonadotrophin. These results confirm those of Hisaw (1944) in the monkey, Katzman *et al.* (1931) in the rat and Bradbury *et al.* (1950) in the human. Whether the corpus luteum was maintained as a functional entity is not known. The fact that heifers in which the corpus luteum was maintained did not exhibit estrus is at least presumptive evidence that they were functional. If the corpora lutea were functional the data imply that the embryo dies first resulting in regression of the corpus luteum. These conclusions are similar to those reached by Wiltbank *et al.* (1956).

The difference between bred heifers and cycling heifers in formation of accessory corpora lutea is interesting. If this difference were real it would give a useful technique to explore the hormonal balance in early pregnancy versus that in the cycling heifer.

The following evidence suggests that regression of the corpus luteum during the estrous cycle of the cow may result from a deficiency of gonadotrophins, presumably LH: (1) estrogen has been shown to cause early regression of the corpus luteum in the cow (Greenstein *et al.*, 1958; Loy *et al.*, 1960; Wiltbank *et al.*, 1961); (2) this induced early regression can be stopped or reversed by injection of gonadotrophins (Wiltbank *et al.*, 1961); and (3) the corpus luteum can be maintained past normal time of re-

TABLE 2. EFFECT OF CHORIONIC GONADOTROPHIN ON FORMATION OF ACCESSORY CORPORA LUTEA IN CYCLING, PREGNANT AND OPEN HEIFERS

Kind of heifer	No. treated[c]	Having accessory c.l.	Time of formation relative to pre-treatment estrus or breeding			
			17th day	21st day	28th day	36th day
		%	no.	no.	no.	no.
Pregnant[a]	27	67	0	5	15	18
Open[b]	12	42	2	3	4	5
Cycling	5	0	..	..	..	..

[a] Twenty heifers had one accessory corpus luteum each and three heifers had two each.
[b] Bred but were found open at time of pregnancy diagnosis.
[c] Intramuscular injection of 1,000 I.U. of human chorionic gonadotrophin from 15th day to the 35th day in bred heifers and from 15th to 26th day in cycling heifers.

TABLE 3. FETAL LOSSES IN HEIFERS FOLLOWING INJECTION OF HUMAN CHORIONIC GONADOTROPHIN

Group	Pregnant heifers	Fetal mortality		
		Early [a]	Late [b]	Total
	no.	no.	no.	no.
Treated	27	3	2	5
Control	26	2	1	3

[a] From 35th day of pregnancy to second pregnancy diagnosis (77 to 85 days after breeding).
[b] Losses from second pregnancy diagnosis to slaughter (134 to 194 days after breeding).

gression by injection of HCG. A high level of estrogen in mid-cycle would provide the mechanism for causing a deficiency of LH or gonadotrophins and consequently regression of the corpus luteum. Asdell (1960) concluded from his studies of the bovine graafiian follicle and from the histochemical studies of the uterus by Moss *et al.* (1954) and Sykes *et al.* (1955) that estrogenic activity is at its greatest during mid-cycle.

Summary

Daily injection of 1,000 I.U. of human chorionic gonadotrophin (HCG) into five cycling heifers from the 15th to the 26th day of the estrous cycle maintained the corpora lutea and lengthened the estrous cycle from 17.7 to 32.4 days. Thirty-nine bred heifers which received HCG from the 15th to the 35th day post-breeding did not show an increase in pregnancy. However, regression of the corpus luteum in bred heifers subsequently diagnosed open occurred earlier in untreated than in treated heifers. It would appear that the embryo dies first and this results in regression of the corpus luteum. Injections of HCG resulted in formation of accessory corpora lutea in 67% of heifers diagnosed pregnant, 42% of the bred heifers diagnosed open and in none of the cycling heifers.

Literature Cited

Asdell, S. A. 1960. Growth in the bovine graafian follicle. Cornell Vet. 50:3.

Bradbury, J. T., W. E. Brown and L. A. Gray. 1950. Maintenance of the corpus luteum and physiologic actions of progesterone. Recent Progress in Hormone Research. 5:151.

Greenstein, J. S., R. W. Murray and R. C. Foley. 1958. Effect of exogenous hormones on the reproductive processes of the cycling dairy heifer. J. Dairy Soc. 41:1834 (Abstr.).

Hisaw, F. L. 1944. The placental gonadotrophins and luteal function in monkeys (macaca mulatta). Yale J. Biol. and Med. 17:119.

Katzman, P. A., L. Levin and E. A. Doisy. 1931. The luteinizing substance of pregnancy urine. Proc. Soc. Exp. Biol. Med. 28:873.

Loy, R. G., R. G. Zimbelman and L. E. Casida. 1960. Effects of injected ovarian hormones on the corpus luteum of the estrual cycle in cattle. J. Animal Sci. 19:175.

Moss, S., T. R. Wrenn and J. F. Sykes. 1954. Alkaline phosphatase, glycogen and periodic acid-Schiff positive substances in the bovine uterus during the estrous cycle. Endocr. 55:261.

Sykes, J. F., S. Moss and T. R. Wrenn. 1955. The distribution of alkaline phosphatase and glycogen in the ovaries and uterus of the bovine. Mich. State Univ. Cent. Sym. Report, Reproduction and Infertility, p. 63.

Wiltbank, J. N., H. W. Hawk, H. E. Kidder, W. G. Black, L. C. Ulberg and L. E. Casida. 1956. Effect of progesterone therapy on embryo survival in cows of lowered fertility. J. Dairy Sci. 39:456.

Wiltbank, J. N., J. E. Ingalls and W. W. Rowden. 1961. Effects of various forms and levels of estrogens alone or in combination with gonadotrophins on the estrous cycle of beef heifers. J. Animal Sci. 20:341.

VOLATILE FATTY ACID CONCENTRATIONS AND PROPORTIONS IN THE GASTROINTESTINAL TRACT OF FULL-FED BEEF HEIFERS[1]

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THE concentrations and proportions of the various volatile fatty acids (VFA) found in sections of the digestive tract other than the rumen have not been clearly established. VFA production is greatest in the zones of the gastrointestinal tract which harbors large quantities of microorganisms (Boyne *et al.*, 1956). Elsden (1945) worked with many different animals and reported that substantial fermentation also occurs in the caecum and colon of mammals. In later work Elsden *et al.* (1946) estimated that in sheep 88% of the total VFA's of the alimentary canal are found in the rumen and in cattle 86%. Annison (1954), working with sheep, found substantial amounts of VFA in the caecum and slight amounts in the colon with much larger quantities in the rumen. Absorption of VFA from various sites along the gastrointestinal tract has been demonstrated by Barcroft *et al.* (1944). Johnston *et al.* (1961), working with dairy calves, concluded that absorption of organic acids occurs from the omasum in significant quantities.

This study was initiated to determine the concentration and proportions of VFA in the rumen, abomasum, small intestine, caecum, and colon of full-fed beef heifers.

Experimental Procedure

Twelve Hereford heifers were selected from a group of 30 that had been on a fattening ration for 210 days at time of slaughter. Selection in the feedlot was on the bases of uniformity of finish and conformation; subsequently the individuals were graded from average good to low choice.

The average daily feed consumption, in pounds, at the time of slaughter was: sorghum silage 10, ground yellow corn 10, alfalfa hay 1, and soybean oil meal 1. Minerals were fed free choice. The animals were fed the amount of feed each morning that they would consume by the next day.

The heifers were slaughtered in a nearby packing plant. They were loaded into a truck for transporting to the plant at 7 a.m. just prior to normal feeding time. After the 20-mile trip, the heifers were put in holding pens without feed or water until slaughtered. All animals were slaughtered between 8 a.m. and noon.

Slaughter was in a conventional manner with about 30 minutes elapsing from the time the animal entered the plant until sampling of the gastrointestinal tract was accomplished. Movement of the tract was held to a minimum. Samples were obtained from the rumen, abomasum, small intestine, caecum, and colon, by slitting the designated organs and dipping into the ingesta with a 100 ml. beaker to obtain sufficient quantities of ingesta to yield fluid for analyses. It was necessary in some cases to make rather long incisions in the small intestine and colon to obtain an adequate sample. Samples taken from the rumen contained a considerable amount of undigested feed; while from the abomasum on, the ingesta had a viscous-like consistency with little undigested feed apparent.

The samples were put in paper cups which were then placed in a sharp freezer with the temperature at 0° F. After the samples had cooled to approximately 32° F., they were put into an insulated chest, that had been pre-cooled to 0° F., and transported to a sharp freezer unit and kept frozen until thawed for analyses. The analytical laboratory procedure used was a modification of that reported by Wiseman and Irvin (1957).

Results and Discussion

Results of the analyses are shown in table 1. Substantial amounts of formic acid were found in the abomasum and small intestine samples with lesser amounts in the caecum and colon. Lactic acid build-up in very sub-

[1] Contribution No. 266, Department of Animal Husbandry.

TABLE 1. VFA PRESENT AND THE PROPORTIONS OF EACH FOUND IN VARIOUS SECTIONS OF THE GASTROINTESTINAL TRACT OF FULL-FED BEEF HEIFERS

Site of sample	mM VFA/100 ml.	Acetic	Propionic	Butyric	Formic	Lactic
		%	%	%	%	%
Rumen	11.902	56.8	26.3	16.8	....	....
Abomasum[a]	1.292	34.9	15.7	19.7	11.7	18.0
Small intestine[b]	1.943	17.9	11.8	33.8	10.8	25.8
Caecum	12.155	41.6	17.3	10.0	5.4	25.7
Colon	11.214	41.6	18.4	11.1	4.0	25.0

[a] Represents 8 samples.
[b] Represents 4 samples.

stantial amounts was noted in the abomasum, small intestine, caecum, and colon.

Total VFA concentrations in the rumen samples were similar to those previously found in work at this station and work reported in the literature review. Levels of VFA in the abomasum samples and the small intestine samples were difficult to determine, and extreme difficulty was experienced in making the fatty acid separations. There appeared to be a correlation between animals and the difficulty encountered in the analysis of samples from these two organs of each animal. Duplicates of the samples revealed that the same samples repeatedly would "plug" the chromatographic columns and slow down or prevent the movement of the solvents and acids through the columns.

Concentrations in the abomasum ranged from 0.609 to 2.463 mM/100 ml. of fluid except that one animal had 11.786, which corresponds to levels found in the rumen, caecum, and colon. This sample had the normal appearance of ingesta from the abomasum. Since abomasum samples may contain rather large quantities of hydrochloric acid (Phillipson and McAnally, 1942), a laboratory test was conducted using procedures identical with those of normal sample analyses but substituting a sample of HC1 solution with pH of slightly over 1.0. Acid activity of 0.526 mM/100 ml. of sample was obtained, indicating that approximately one-half of the total titratable acidity attributed to the abomasum samples could be accounted for as HC1 found in gastric secretions.

The VFA concentrations for the small intestine varied from 1.607 to 5.446 mM/100 ml. of fluid. As previously indicated, they were very difficult to move through the chromatographic columns.

The average total concentration of VFA in the caecum and colon of 12.155 and 11.214 mM/100 ml., respectively, was very close to that observed in the rumen. Analyses of samples from these portions of the tract proceeded in much the same way as with rumen samples except that substantial amounts of formic and lactic acids were present, whereas only a trace of these acids appeared in rumen samples. Data from these samples indicated that concentrations of VFA in the rumen, caecum, and colon are about equal, with lesser total amounts in the abomasum and small intestine.

Although comparable data for cattle seem to be lacking in the literature, the results of this experiment are similar to those reported by Boyne *et al.* (1956) for sheep. They found VFA concentrations of the rumen, abomasum, small intestine, caecum, and colon to be respectively, 11.4, 0.64, 2.5, 9.9, and 9.8 mM/110 ml. of sample. Average quantities for the respective organs reported in this paper were 11.9, 1.3, 1.9, 12.2, and 11.2.

Proportions of VFA present in the gastrointestinal tract varied greatly among individual animals, with changes apparent in the proportion of certain VFA as the ingesta moved through the alimentary canal. Rumen samples contained only acetic, propionic and butyric acids in quantity with abomasum and small intestine samples containing substantial proportions of formic acid with lesser proportions of the same acid found in the caecum and colon samples. Lactic acid was found in substantial amounts in each organ sampled except the rumen.

Summary

Samples from five sections of the gastrointestinal tract of 12 full-fed heifers were taken immediately after slaughter and frozen until prepared for VFA analyses. Proportions of acetic, propionic, and butyric acids in the rumen appeared to be normal. Substantial amounts of formic and lactic acids were found in the abomasum and small intestine along with acetic, propionic, and butyric acids. Slight quantities of formic and substan-

tial amounts of lactic acids also were found in the caecum and colon. Millimoles of VFA/100 ml. of sample in the rumen, abomasum, small intestine, caecum, and colon were respectively, 11.902, 1.292, 1.943, 12.155, and 11.214.

Literature Cited

Annison, E. F. 1954. Some observations on volatile fatty acids in the sheeps rumen. Biochem. J. 57:400.

Barcroft, J., R. A. McAnally and A. T. Phillipson. 1944. Absorption of volatile fatty acids from the alimentary tract of the sheep and other animals. J. Exp. Biol. 20:120.

Boyne, A. W., R. M. Campbell, J. Davidson and D. P. Cuthbertson. 1956. Changes in composition of the digesta along the alimentary tract of sheep. Brit. J. Nutr. 10:325.

Elsden, S. R. 1945. The fermentation of carbohydrates in the rumen of sheep. J. Exp. Biol. 22:51.

Elsden, S. R., M. W. S. Hitchcock, R. A. Marshall and A. T. Phillipson. 1946. Volatile acids in the digesta of ruminants and other animals. J. Exp. Biol. 22:191.

Johnston, Jr., R. P., E. M. Kesler and R. D. McCarthy. 1961. Absorption of organic acids from the omasum. J. Dairy Sci. 44:331.

Phillipson, A. T. and R. A. McAnally. 1942. Studies on the fate of carbohydrates in the rumen of sheep. J. Exp. Biol. 19:199.

Wiseman, H. G. and H. M. Irvin. 1957. Determination of organic acids in silage. J. Agr. and Food Chem. 5:213.

EFFECT OF PELLET SIZE AND COMPOSITION ON FEEDLOT PERFORMANCE, CARCASS CHARACTERISTICS AND RUMEN PARAKERATOSIS OF FATTENING STEERS

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MANY experiments have indicated that high roughage rations finely ground and pelleted will improve feedlot performance of cattle and sheep (Webb *et al.*, 1957; Weir *et al.*, 1959; Meyer *et al.*, 1960b; McCroskey *et al.*, 1961). Increased food intake, with an increased rate of digestion (Esplin *et al.*, 1957; Meyer *et al.*, 1959a,b), is apparently associated with the improved performance. The pelleting of rations containing concentrate have shown more variable results and food intake has been depressed in some experiments (Weir *et al.*, 1959; Beardsley *et al.*, 1959; McCroskey *et al.*, 1961). Church and Fox (1959) found no significant differences in response of lambs fed 1/4", 3/8" or 1/2" high roughage pellets containing hay ground through 3/32", 3/16" and 1/4" screens. No comparable experiment with steers has been reported.

Rumen parakeratosis has been observed in lambs fed pelleted rations (Jensen *et al.*, 1958; Hopkins *et al.*, 1960; Thompson *et al.*, 1958) and in steers (Beardsley *et al.*, 1959). Pelleted rations have not been solely responsible for this condition (Vidacs and Ward, 1960).

The trials reported in this paper were designed to study the effect of pellet size (particle size within the pellet may be of primary importance) and composition on the feedlot performance of steers and to determine the incidence and severity of rumen parakeratosis as effected by the experimental treatments.

Experimental

The experiments conformed to specifications outlined by Meyer *et al.* (1960a) in regard to reducing errors in beef cattle feeding trials. Carcass specific gravity was used to correct all carcass weights to an equivalent caloric content with subsequent analysis of covariance to adjust the corrected carcass weights to equal initial weights. Other data were examined by the analysis of variance, with the multiple range test of Duncan (LeClerg, 1957) to determine the significance of differences between pairs of means.

Trial I. Twelve steers were randomly selected for immediate slaughter from a group of 72 long yearlings of mixed breeding. The remaining animals were divided into 20 lots. Replicated lots received either a ration of 100% alfalfa hay or one containing a mixture of 50% alfalfa, 37.5% barley and 12.5% molasses beet pulp.

The barley in all instances was prepared by hammermill (3/8" screen). The beet pulp was used as commercially produced without alteration. Four methods of feed preparation and the size hammermill screen used to grind the roughage were: milled, 1"; 1/4" pellet, 1/16"; 5/8" pellet, 3/8"; 4" diameter wafer, 1.5". The fifth method of feed preparation was an experimental field pelleting machine. This machine was used as a stationary unit and formed wafers approximately 3 in. square from the same lot of hay used in the other rations. Concentrate was not incorporated into the square wafer, but fed with it in the proportions previously indicated. All animals were fed *ad libitum* for 140 days.

An eating and ruminating behavior study was conducted by observing each animal once every 15 min. for a 24-hour period.

Trial II. Nine lots of steers were randomly formed from a group of 108 Angus yearlings. One lot was slaughtered immediately, four lots were assigned to a ration of 100% alfalfa hay and four lots to a ration composed of 40% alfalfa, 45% barley grain and 15% molasses beet pulp. The ration ingredients were ground in exactly the same way as for Trial I and fed as milled, 1/4" pellets, 5/8"

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pellets and as the 4″ wafer (split at its diameter when extruded from the machine). Sixty percent concentrate could not be satisfactorily incorporated into the wafer and maintain a product suitable for bulk handling. The wafer was thus composed of 60% alfalfa and 40% concentrate with additional concentrate being supplied at the feed bunk to produce the proper ratio of 40% hay and 60% concentrate.

Each prepared ration was fed alone, with antibiotic added to provide 75 mg. chlortetracycline hydrochloride per head per day and with an allowance of long oat hay. The subtreatments were included to determine their effect on rumen parakeratosis. A behavior study was conducted as in Trial I. The experimental period was 133 days.

At slaughter each rumen was identified and examined for rumen parakeratosis. A subjective rating of 0 to 4 was given to numerically estimate the incidence and severity of the disease. Steers from all treatments had been held in one large pen before slaughter and thus examination of the rumina was completely at random. The examiner did not know the experimental treatments involved.

Results

Trial I. Feeding Trial. As shown in table 1 steers fed the all-alfalfa ration had nearly identical feedlot performance regardless of how the hay was prepared. There were no significant differences in adjusted fat—corrected carcass weights, daily gains or dressing percents that could be attributed to the manner of processing the hay before feeding. Daily dry matter consumption corrected for differences in body size by the parameter $w^{3/4}$ was significantly ($P<.05$) lower for those steers receiving the experimental wafer than for all other treatments.

The 1:1 alfalfa concentrate ration resulted in a larger fat-corrected carcass weight ($P<.05$) for the steers fed the experimental wafer than those fed the same feed in milled form. Daily gains followed a similar pattern. Food intake corrected for differences in body size was significantly ($P<.01$) lower for animals receiving the 1:1 ration in milled form or finely ground in a 1/4″ pellet than for those receiving the ration prepared in other ways. Differences in dressing percent or carcass fat were not significant.

Observations of the interior rumen wall at

TABLE 1. TRIAL I. RESPONSE OF STEERS FED RATIONS PREPARED BY DIFFERENT PELLETING METHODS

Feed preparation	Milled		1/4″ Pellet		5/8″ Pellet		4″ Wafer		Experimental wafer	
Ration	Alfalfa 100%	Alfalfa 50% Conc. 50%	Alfalfa 100%	Alfalfa 50% Conc. 50%	Alfalfa 100%	Alfalfa 50% Conc. 50%	Alfalfa 100%	Alfalfa 50% Conc. 50%	Alfalfa 100%	Alfalfa 50% Conc. 50%
No. of animals	6	6	6	6	6	6	6	6	6	6
Initial weight, lb.	624	646	609	681	605	647	607	607	619	660
Daily weight gain, lb.	2.00	2.03$_b$	2.00	2.08$_b$	2.09	2.51$_a$	2.13	2.20$_{a,b}$	1.86	2.66$_a$
Daily energy gain, mcal.	3.80	4.28	3.20	4.76	4.16	5.34	4.28	4.54	3.61	5.01
Daily dry matter intake, lb.	19.2	15.6^a	19.2	17.2^a	19.9	19.8	19.8	18.5	17.9^a	19.6
Carcass data:										
Dressing percent	58.2	60.1	59.2	61.1	58.8	60.4	57.9	60.1	57.2	60.2
Carcass fat, %	19.5	21.3	16.9	22.6	20.9	23.1	21.3	21.7	19.7	25.3
Corrected carcass,[c] lb.	530	566$_b$	504	598$_{a,b}$	567	642$_{a,b}$	569	602$_{a,b}$	508	682$_a$
Feed conversion:										
Weight gain/100 lb. feed	10.4	13.0	10.4	12.1	10.5	12.7	10.8	11.9	10.4	13.6
Energy gain mcal./100 lb. feed	19.8	27.4	16.7	27.7	20.9	27.0	21.6	24.5	20.2	22.9

[a, b] Differences are significant if comparable means do not have a common subscript ($P<.05$) or superscript ($P<.01$). No letter or the same letter on comparable means indicates no significant differences.

[c] As suggested by Meyer *et al.* (1960a).

time of slaughter indicated a severe incidence of rumen parakeratosis (confirmed by histological examination) similar to that described by Jensen *et al.* (1958) in lambs. The disease was most prevalent in animals that had been fed the finely ground roughage prepared in 1/4″ or 5/8″ pellets, but a minor incidence was also noted in the groups fed roughage ground through 1″ or 1.5″ hammermill screens. It is not known how this disease affected the results of this trial.

Trial II. Feeding Trial. Table 2 gives the results of that portion of the second trial that compares the feedlot response of steers fed two rations prepared by four different methods.

percent or average daily gain that could be attributed to either the antibiotic or the long oat hay supplement when the trial was considered as a unit. (These data are not shown in this paper.) However, if the response of only those steers fed the 1/4″ or 5/8″ pelleted ration are considered then oat hay was effective in permitting or promoting a heavier ($P<.05$) adjusted fat corrected carcass than comparable steers receiving the pelleted rations without long oat hay. There were no significantly different responses that could be attributed to the antibiotic in any comparison.

Trial II. Rumen Parakeratosis Observation. Table 3 is a summary of the average subjective ratings given to evaluate the inci-

TABLE 2. TRIAL II. RESPONSE OF STEERS FED RATIONS PREPARED BY DIFFERENT PELLETING METHODS

Feed preparation	Milled		1/4″ Pellet		5/8″ Pellet		4″ Split wafer	
Ration	Alfalfa 100%	Alfalfa 40% Conc. 60%	Alfalfa 100%	Alfalfa 40% Conc. 60%	100% Alfalfa	40% Alfalfa Conc. 60%	100% Alfalfa	40% Alfalfa Conc. 60%
No. of animals	12	12	12	12	12	12	12	12
Initial weight, lb.	736	721	729	732	724	736	742	738
Daily weight gain, lb.	1.98$_b$	2.63	1.91$_b$	2.56	2.26$_a$	2.67	2.10$_{ab}$	2.82
Daily energy gain, mcal.	4.82	7.01	4.09	6.64	5.46	6.48	5.08	7.67
Daily dry matter intake, lb.	23.9$_{ab}$	21.9$_{ab}$	22.7$_b$	21.0$_b$	24.2$_{ab}$	20.9$_b$	25.2$_a$	23.9$_a$
Carcass data:								
Dressing percent	60.2	62.7	59.5	61.1	60.7	61.6	60.8	62.1
Carcass fat, %	23.1	27.5	20.4	26.6	24.0	25.3	23.1	28.3
Corrected carcass,[c] lb.	651$_{ab}$	832$_{ab}$	603$_a$	778$_b$	709$_b$	774$_b$	670$_b$	857$_a$
Feed conversion:								
Weight gain/100 lb. feed, lb.	8.3	12.0	8.4	12.2	9.3$_a$	12.8	8.3	11.8
Energy gain/100 lb. feed, mcal.	20.1	32.0	18.0	31.6	22.6	31.0	20.2	32.0

[a, b] Differences are significant if comparable means do not have a common subscript ($P<.05$) or superscript ($P<.01$). No letter or the same letter on comparable means indicates no significant difference.
[c] As suggested by Meyer *et al.* (1960$_a$).

Adjusted fat-corrected carcass weights were greater ($P<.05$) from steers that received the all alfalfa hay ration in the 5/8″ pellet or in the 4″ split wafer than for those consuming the hay finely ground in a 1/4″ pellet. Feed intake corrected for differences in body size by the parameter $w^{3/4}$ was greater ($P<.05$) when fed as the wafer compared to a 1/4″ pellet. More rapid gains were made ($P<.05$) on the 5/8″ pellet compared to the 1/4″ pellet or milled hay.

Steers receiving the 60% concentrate ration in wafer form produced larger adjusted fat corrected carcasses and consumed more feed than comparable animals fed the same feed more finely ground as 1/4″ or 5/8″ pellets ($P<.05$).

There were no significant differences between or within methods of feed preparation among the means for adjusted fat corrected carcass weight, feed consumption, dressing

dence and severity of rumen parakeratosis in the steers as affected by the addition of an antibiotic or long oat hay to the rations prepared by different methods.

Analysis of variance indicated significantly lower scores ($P<.01$) for rumina from the steers receiving the more coarsely ground rations fed in milled or wafered form. The rumen scores for steers receiving a 5/8″ pellet were lower ($P<.05$) than those fed the more finely ground feed in a 1/4″ pellet.

Long oat hay lowered parakeratosis scores ($P<.01$) but antibiotic was without effect.

A significant interaction between rations and parakeratosis treatments (antibiotic and oat hay) was apparently due to a greater decrease in severity of rumen parakeratosis in the steers receiving the pelleted concentrate ration plus long oat hay compared to those consuming the pelleted all alfalfa ration with long hay supplementation. A significant inter-

TABLE 3. TRIAL II. RUMEN PARAKERATOSIS SCORES[c]

Treatment	Feed preparation and ration[d]							Mean
	M 0	M 60	1/4" 0	1/4" 60	5/8" 0	5/8" 60	W 0	W 60	
Control	0.1	0.9	3.6	3.5	2.8	3.4	0.6	1.2	2.0
Antibiotic	0.9	0.8	3.9	3.6	2.5	3.1	0.9	0.9	2.1
Oat hay[e]	0.5 (0.5)	0.5 (0.4)	3.8 (1.1)	2.6 (1.0)	2.0 (0.8)	0.4 (0.8)	0.2 (0.2)	0.6 (1.1)	1.3[a] (0.7)
Ration mean	0.5	0.7	3.8[a]	3.2[a]	2.4[b]	2.3[b]	0.6	0.9	...

[a, b] Differences are significant if comparable means do not have a common subscript ($P<.05$) or superscript ($P<.01$). No letter or the same letter on comparable means indicates no significant difference.
[c] Subjective rating from 0 to 4 as severity of parakeratosis increased. Each figure is the average of 4 observations. Initial slaughter cattle scored 0.1.
[d] M and W refer to milled and wafered rations; 1/4" and 5/8" are pellet diameters; 0 or 60 refer to concentrate level.
[e] Figure in parenthesis is the average daily consumption on long oat hay on a dry basis.

action between methods of feed preparation and parakeratosis treatment could possibly be due to oat hay having little effect on the minor incidence of rumen parakeratosis in the milled or wafer fed groups.

Trial I and II. Eating and Ruminating Behavior. The means for eating and ruminating times as obtained during the 24-hour behavior studies are reported in table 4. The results were quite similar each year and the combined averages are given. Analysis of variance indicated that steers fed the more finely ground pelleted rations spent less time eating ($P<.01$) than those consuming the wafered or milled feeds. The steers on the all hay ration spent more time eating than those receiving the hay and concentrate.

TABLE 4. THE INFLUENCE OF RATION AND METHOD OF FEED PREPARATION ON EATING AND RUMINATING BEHAVIOR OF FEEDLOT STEERS[a]

Ration	Trial I & II averages		
	Eating time, %	Ruminating time, %	Ratio RT/ET
Milled, hay	15	22	1.5
Milled, hay and conc.	11	12	1.1
1/4" pellet, hay	10	5	0.5
1/4" pellet, hay and conc.	8	10	1.2
5/8" pellet, hay	10	12	1.2
5/8" pellet, hay and conc.	8	11	1.4
Wafer, hay	14	16	1.1
Wafer, hay and conc.	10	14	1.4

[a] Each steer was observed once every 15 minutes during a 24-hour period.

A significant interaction ($P<.01$) was indicated between methods of feed preparation and rations when ruminating times were compared. This interaction is probably a result of the finely ground all hay ration (1/4" pellet) eliciting less rumination than the hay plus the concentrate. The reverse situation is apparent in other similar comparisons. Steers fed the coarser ground feeds (milled and wafered rations) spent a longer time ruminating than animals receiving the more finely ground rations.

Discussion

The results of these trials do not indicate a consistent pattern of response when steers were fed an all-alfalfa hay ration or a ration containing 50 or 60% concentrate prepared in different pellet sizes. Rumen parakeratosis may have influenced the performance of steers fed the more finely ground feeds in 1/4" and 5/8" pellets. Jensen *et al.* (1958) have shown that lambs with rumen para-

keratosis do not gain as rapidly as similarly fed lambs without the disease.

The cause of rumen parakeratosis cannot be determined from this trial, but it is apparently associated to some extent with feed particle size. Physiological changes as a result of physical differences in the feed are apparently primarily involved (Vidacs and Ward, 1960). It is likely that the proportions of the volatile fatty acids produced by identical rations prepared by the different pelleting processes (the feed particle size within the pellet being of primary importance) was altered (Blaxter and Graham, 1956). Balch and Rowland (1957) using fistulated milking dairy cows have observed a decrease in the ratio of acetic to propionic acid when finely ground hay was substituted for long hay in a ration composed of approximately equal amounts of hay and concentrate. An increased rate of fatty acid production on finely ground pelleted alfalfa compared to chopped alfalfa as shown by Meyer *et al.* (1959a) coupled with less rumination and a likely decrease in the buffering capacity of the rumen possibly leads to factors predisposing to rumen parakeratosis. It is conceivable that there are certain fundamental similarities between dietary regimes that result in rumen parakeratosis and those that have a depressing effect on the butterfat content of milk.

The trials reported here indicate no significant differences in the feeding value of alfalfa hay fed in the milled form or as the large 3″ or 4″ wafers. This agrees with the observations of Meyer *et al.* (1959b). Any economical advantage of feeding hay wafers will probably have to be a result of labor savings due to their handling characteristics rather than through improved feeding value. It was, however, apparent in these trials that the wafered material was readily accepted by the animals and satisfactory performance was obtained by feeding ground concentrate with the hay wafers.

Summary

Rumen parakeratosis may have influenced the results in two experiments in which the influence of fineness of grind and pelleting of ration constituents on the feedlot performance of yearling steers was studied. There were no consistent patterns of response to an all-alfalfa hay ration or to one containing 50 or 60% concentrate when fed as 1/4″ and 5/8″ pellets or as 4″ wafers and regular milled feed.

The incidence and severity of rumen parakeratosis was greatest in steers receiving the finely ground feed in 1/4″ or 5/8″ pellets. The level of concentrate or the addition of an antibiotic did not affect the disease significantly. Long oat hay fed in limited amounts was effective in reducing the severity of the parakeratosis but did not eliminate it. Steers fed long oat hay with the finely ground pelleted rations (1/4″ and 5/8″) made significantly greater gains and had larger fat corrected carcass weights than animals receiving the pellets alone.

Literature Cited

Balch, D. A. and S. J. Rowland. 1957. Volatile fatty acids and lactic acid in the rumen of dairy cows receiving a variety of diets. British J. Nutr. 11:288.

Beardsley, D. W., W. C. McCormick and B. L. Southwell. 1959. Steer performance on and rumen effects of different concentrate: roughage ratios in pelleted and unpelleted mixed fattening rations. J. Animal Sci. 18:1507 (Abstr.).

Blaxter, K. L. and N. McC. Graham. 1956. The effect of the grinding and cubing process on the utilization of the energy of dried grass. J. Agr. Sci. 47:207.

Church, D. C. and C. W. Fox. 1959. Effect of pellet size and roughage grind on performance of lambs. J. Animal Sci. 18:1168 (Abstr.).

Esplin, A. L., U. S. Garrigus, E. E. Hatfield and R. M. Forbes. 1957. Some effects of pelleting a ground mixed ration on feed utilization by fattening lambs. J. Animal Sci. 16:863.

Hopkins, H. A., J. P. Fontenot and W. M. Mestanza. 1960. Effect of grinding and pelleting on feedlot performance digestibility and incidence of rumen parakeratosis in lambs. J. Animal Sci. 19:652 (Abstr.).

Jensen, R. J., C. Flint, R. H. Udall, A. W. Deem and C. L. Seger. 1958. Parakeratosis of the rumens of lambs fattened on pelleted feed. Am. J. Vet. Res. 19:277.

LeClerg, E. L. 1957. Mean separation by the functional analysis of variance and multiple comparisons. Agricultural Research Service, 20–3.

McCroskey, J. E., L. S. Pope, D. F. Stevens and George Waller. 1961. Effect of pelleting steer-fattening rations of different concentrate to roughage rations. J. Animal Sci. 20:42.

Meyer, J. H., R. L. Gaskill, G. S. Stoewsand and W. C. Weir. 1959a. Influence of pelleting on the utilization of alfalfa. J. Animal Sci. 18:336.

Meyer, J. H., G. P. Lofgreen and W. N. Garrett. 1960a. A proposed method for removing sources of error in beef cattle feeding experiments. J. Animal Sci. 19:1123.

Meyer, J. H., W. C. Weir, J. B. Dobie and J. L. Hull. 1959b. Influence of the method of preparation on the feeding value of alfalfa hay. J. Animal Sci. 18:976.

Meyer, J. H., W. C. Weir, L. G. Jones and J. L. Hull. 1960b. Effect of stage of maturity, dehydrating versus field-curing and pelleting on alfalfa hay quality as measured by lamb gains. J. Animal Sci. 19:283.

Thompson, G. B., L. D. Kintner and W. H. Pfander. 1958. Some effects of ration preparation on alternations of the rumen mucous membrane. J. Animal Sci. 17:1220 (Abstr.).

Vidacs, G. and G. M. Ward. 1960. Parakeratosis condition of rumen epithelium produced by an all-concentrate ration. J. Dairy Sci. 43:875 (Abstr.).

Webb, R. J., G. F. Cmarik and H. A. Cate. 1957. Comparison of feeding three forages as baled hay, chopped hay, hay pettets and silage to steer calves. J. Animal Sci. 16:1057 (Abstr.).

Weir, W. C., J .H. Meyer, W. N. Garrett, G. P. Lofgreen and N. R. Ittner. 1959. Pelleted rations compared to similar rations fed chopped or ground for steers and lambs. J. Animal Sci. 18:805.

BIOCHEMICAL AND MICROSCOPIC COMPARISON OF *IN VIVO* AND *IN VITRO* RUMEN FERMENTATIONS [1, 2, 3]

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FERMENTATIONS *in vitro* in an all-glass system have been used in this laboratory for studying some of the nutritional requirements of rumen micro-organisms responsible for cellulose breakdown (Bentley *et al.*, 1954; Dehority *et al.*, 1957; Johnson *et al.*, 1958). The technique has recently been applied to the study of cellulose digestion in forages and the results have been correlated with forage cellulose digestion *in vivo* (Quicke *et al.*, 1959). Using a similar *in vitro* rumen fermentation technique, Hershberger *et al.* (1959) found a high correlation between the digestible energy (or TDN) of a forage and its cellulose digestibility *in vitro*.

However, the authenticity of micro-organisms which ferment cellulose and other food constituents *in vitro* has been doubted by some workers (Baker, 1943; Sijpesteijn, 1948; Warner, 1956) especially when fermentations were carried out for long periods. Therefore, a study was undertaken to compare *in vivo* with *in vitro* rumen fermentations.

Experimental

A steer fitted with a permanent rumen fistula and maintained on good quality mixed hay, and two sheep were used in the present study. For the volatile fatty acid production experiments with sheep, rumen liquor samples were drawn from and substrate mixtures delivered to the rumen by stomach tube. However, these animals were fistulated prior to the experiments in which nylon bags filled with filter paper were placed in the rumen to estimate rate of cellulose digestion. The sheep were fed a purified diet of 60% cellulose,[6] 14% starch, 20% corn sugar (cerelose), 3% urea and 3% minerals (1.5 parts Ca_3PO_4, 0.5 parts $Ca\ CO_3$ and 1 part common salt). Experiments with the sheep were preceded by preliminary feeding periods of at least 14 days. It was necessary to feed some hay to promote consumption of the purified diet. The hay was stopped, however, a week before each particular experiment was started.

The sheep were fasted for a period of 20 hours before the start of a volatile fatty acid production experiment. This period was found in a preliminary experiment to be sufficient for the volatile fatty acids in the rumen to attain a constantly declining level. A sample of rumen fluid was then obtained from the sheep, and the bacteria separated as described below. These bacteria were used as inoculum for the *in vitro* fermentation studies. One hundred gm. of purified cellulose (Solka-floc) were suspended in 200 ml. of *in vitro* basal medium containing 5 gm. of urea and then introduced into the animal's rumen so that the bacteria *in vitro* and *in vivo* would be growing on essentially the same substrate in the same media.

In Vitro Fermentation. The rumen bacteria used as inoculum for the *in vitro* fermentations were prepared by sedimentation with a Sharples super centrifuge, as described by Bentley *et al.* (1954), and modified by Dehority *et al.* (1957). When whole rumen juice was used as the inoculum, 40 ml. of the strained juice was added to the basal medium in each flask. The basal medium and *in vitro* method used for these studies have been previously described by Dehority *et al.* (1957).

Total Volatile Fatty Acids. Two-ml. aliquots of fermentation liquor, deproteinized according to the method of Warner (1956), were analyzed for total volatile fatty acids (VFA) by steam distillation. Estimation of individual volatile fatty acids was achieved by separation on silica gel columns prepared according to Bulen *et al.* (1952), n-butanol-benzene mixtures being used for elution (Linke, 1952).

Cellulose Digestion. The rate of cellulose

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[3] The authors wish to express their appreciation to H. Scott for technical assistance with several phases of this study.

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[6] Solka-floc BW-40, Brown Company, Berlin, New Hampshire.

digestion *in vivo* by both the steer and sheep was estimated with a nylon bag technique. At the start of a cellulose digestion trial, 12 nylon bags (1.5″ x 3″) each containing 1.0 gm. of small pieces of Whatman No. 1 filter paper, were inserted into the rumen through the fistula. Two bags were removed after 3, 6, 12, 24, 30 and 48 hours. The contents of the bags were transferred quantitatively into centrifuge tubes and cellulose was determined according to the method of Crampton and Maynard (1938). In the *in vitro* trials, similar tubes containing 1 gm. of filter paper and the basal media were inoculated with 20 ml. of rumen liquor. Cellulose digestion was estimated at the same time intervals as used in the *in vivo* trials.

Microscopic Examination. The bacteria from the rumen and from the fermentation flasks were examined after incubation periods of 24–30 hours. The slides were prepared by staining with the regular Gram stain (Hucker modification) or with nigrosine.

Results and Discussion

Cellulose Diet

Biochemical Data. Figure 1-A shows the rate of volatile fatty acid production in the rumen of a sheep after introducing the cellulose-basal media-urea mixture. Figure 1-B presents the same information for the corresponding *in vitro* fermentations on the same substrate. The curves represent the results of four experiments in which both *in vivo* and *in vitro* fermentations were recorded. In the first 12 hours (for curves A and B only) the best straight line was calculated by the regression formula and was joined to the 24-hour mean value. From these curves (A and B) it would appear that there is a certain degree of parallelism between *in vivo* and *in vitro* VFA production in the first 12 hours. When the whole rumen juice was used as inoculum *in vitro*, there was a greater rate of VFA production as evidenced from the slopes of the curves (Fig. 1, A and C). Since it was realized that production of some of the acids may be due to remaining food particles in the rumen or even to dead bacteria, an experiment was carried out whereby 5 gm. urea and the mineral mixture with no cellulose substrate was introduced into a fasting sheep and VFA production was determined at intervals thereafter (Fig. 1, D). The results showed an increase in volatile fatty acids up to 5 hours after which the level steadily declined. A blank curve was also obtained for the *in vitro* study with whole rumen juice (Fig. 1, E).

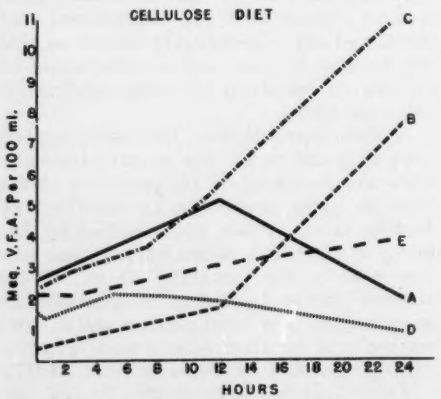

Figure 1. Total volatile fatty acid production from in vivo and in vitro fermentation of cellulose by sheep rumen bacteria.
A. In vivo—average of four experiments.
B. In vitro—average of four experiments (2 flasks per experiment).
C. In vitro—average of two experiments using whole rumen juice as inoculum.
D. In vivo—control experiment—no cellulose added.
E. In vitro—control experiment—using whole rumen juice as inoculum—no cellulose added.

The component volatile fatty acids produced during the fermentation *in vivo* and *in vitro* are shown in table 1. These results show comparable proportions of acetic acid and propionic acid in the *in vivo* and *in vitro* fermentations. Very little C_4 acids and higher homologues were found in the mixtures.

These VFA data suggested that the digestion of cellulose *in vitro* was proceeding at rates similar to *in vivo* rates. However, it is difficult to compare VFA results obtained *in vitro* and *in vivo* especially after 12-hour fermentations, owing to absorption from the rumen and passage into other parts of the alimentary canal. Thus, for confirmation, nylon bags containing filter paper were inserted into the rumen through a permanent fistula and used to follow the rate of cellulose digestion for 48 hours. Figure 2 gives the rates of cellulose digestion obtained with filter paper used both *in vitro* and in the nylon bags *in vivo*. For this work the sheep were maintained on the purified cellulose diet, while the steer was fed a diet of mixed hay. In both the steer and sheep data a striking similarity was observed between the *in vivo*

TABLE 1. COMPONENT VOLATILE FATTY ACIDS PRODUCED *IN VIVO* AND *IN VITRO* WITH PURIFIED CELLULOSE AS THE SOLE CARBOHYDRATE SOURCE [a]

Site		Mole % of T.V.F.A.[b]		
		Butyric and higher	Propionic	Acetic
In vivo [c]	Exp. I	12.2	40.0	48.3
	Exp. II	9.5	51.5	39.0
	$\bar{x}$	10.8	45.8	43.6
In vitro [d]	Exp. I	5.4	43.0	51.6
	Exp. II	8.6	45.4	46.1
	$\bar{x}$	7.0	44.2	48.8

[a] Inoculum for the *in vitro* test was obtained from the sheep just prior to the *in vivo* test.
[b] Total volatile fatty acids.
[c] Each value is the average of duplicate determinations in each experiment.
[d] Each value is the average of determinations on duplicate flasks in each experiment.

and *in vitro* fermentations with a lag period of about six hours. The highest rate of cellulose digestion occurred between 24 and 30 hours and in this period the rates *in vitro* and *in vivo* were very similar in both the steer and the sheep. These data support the conclusions suggested by the VFA data.

Microscopic Examination. Photomicrographs are shown in figure 3. Examination of slides of rumen bacteria stained with nigrosine or the Gram-stain showed the presence of most of the morphological shapes reported by Baker and Martin (1937, 1939) and by Moir and Masson (1952). There was a preponderance of Gram-negative bacteria, particularly Gram-negative micrococci (0.5–0.8μ) and very small Gram-negative rods (1–1.5 x 0.5μ) in the rumen inoculum (Fig. 3a). Slides prepared from *in vitro* fermentations with pure cellulose or from rumen liquor collected 24 hours after cellulose introduction into the rumen showed a marked proliferation of Gram-negative micrococci (Fig. 3 b, c and d). In addition, there appeared to be a smaller, but definite proliferation of Gram-negative small rods. From these observations and other work by Dehority *et al.* (1960), the authors conclude that these organisms are responsible for a large portion of the cellulose digestion occurring in the rumen and are true representatives of the cellulolytic microflora.

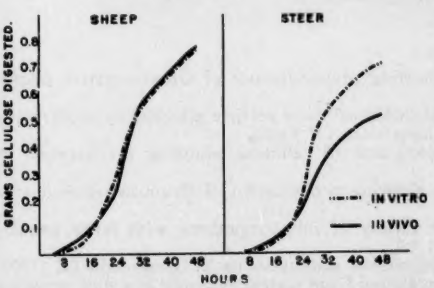

Figure 2. Comparison of the rates of in vivo and in vitro cellulose digestion.

Other Diets

The comparison of the *in vitro* and *in vivo* fermentations was extended to include results obtained with other purified diets fed to sheep and a normal diet of mixed hay fed to a steer. One purified diet contained a high percentage of starch and in another one casein replaced urea as a source of nitrogen. In general, the VFA data obtained in these comparisons were inconclusive, presumably as the result of sampling errors and/or differential fatty acid absorption rates. Therefore, no valid conclusions could be made. However, microscopic examination of bacteria from *in vivo* and *in vitro* experiments with the steer on a mixed hay diet revealed a definite similarity of the microflora (Fig. 3 e and f). From these observations it appeared that during incubation periods of 24–30 hours the micro-organisms cultured *in vitro* are representative of those in the rumen when hay is used as a substrate both *in vivo* and *in vitro*. When the inoculum from the hay fed steer was incubated *in vitro* with purified cellulose, an obvious proliferation of the Gram-negative micrococci was observed (Fig. 3 g).

Summary

A comparison of *in vivo* with *in vitro* cellulose fermentation by rumen micro-organisms was undertaken, based on rate of fermenta-

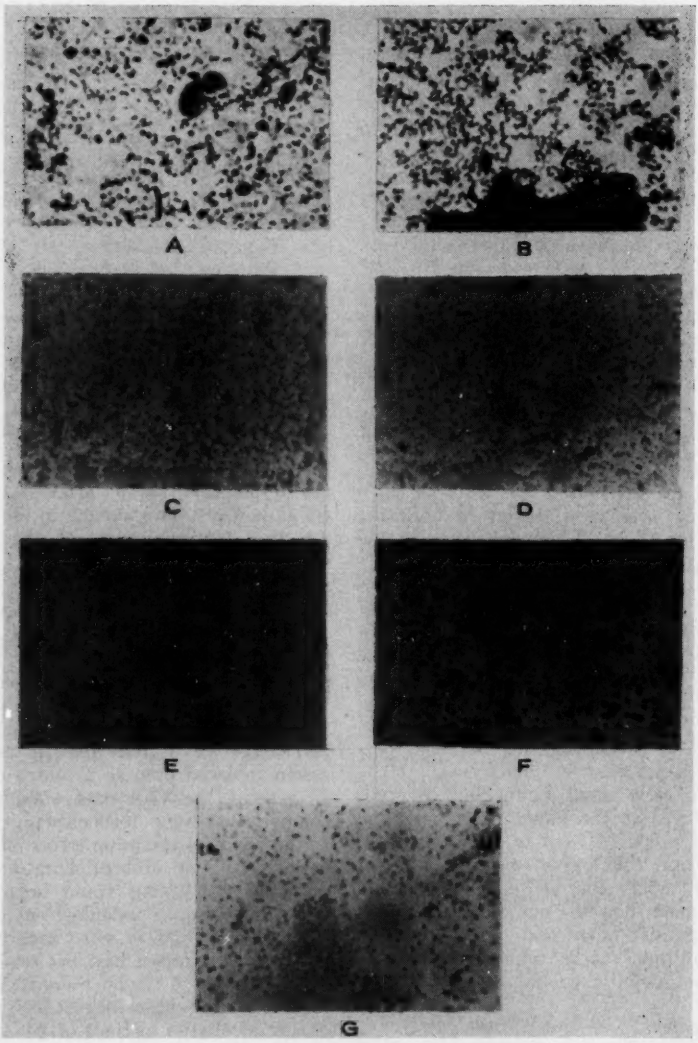

Figure 3

A. Rumen fluid from sheep on cellulose diet showing preponderance of Gram-negative micrococci. Gram stain (X 1100).

B. In vitro fermentation of cellulose (30 hours) showing cellulose particle attacked by proliferated Gram-negative micrococci and very small rods. Gram stain (X 1100).

C. Rumen fluid from sheep 24 hours after introduction of cellulose, showing proliferation of Gram-negative micrococci. Gram stain (X 1100).

D. In vitro fermentation of cellulose (24 hours) showing proliferation of Gram-negative micrococci. Grain stain (X 1100).

E. Rumen fluid from steer on hay diet showing variety of microorganisms with large population of Gram-negative micrococci. Gram stain (X 1100).

F. In vitro fermentation of hay (24 hours) showing similar microflora as E. Gram stain (X 1100).

G. In vitro fermentation of cellulose. Inoculum prepared from a steer fed on a hay diet, showing proliferation of Gram-negative micrococci. Gram stain (X 1100).

tion (as measured by volatile fatty acid production and the nylon bag technique), quantitative identification of end-products of fermentation and microscopic examination of bacteria.

The rates of cellulose digestion and production of volatile fatty acid end-products in the *in vivo* and *in vitro* fermentations were similar under the conditions used in these experiments. Gram-negative micrococci, which were found in large numbers *in vivo*, proliferated *in vitro* and *in vivo* on purified cellulose. When mixed hay was used as a substrate both *in vivo* and *in vitro*, fermentations could be carried out *in vitro* for periods of 24–30 hours without any marked morphological change in the bacterial population.

Literature Cited

Baker, F. 1943. Direct microscopical observations upon the rumen population of the ox. I. Qualitative characteristics of the rumen population. Ann. Appl. Biol. XXX:230.

Baker, F. and R. Martin. 1937. Some observations of the iodophile microflora of the caecum of the rabbit with special regard to the disintegration of cell wall substances. Zentral. Fur Bakteriol. 96:18.

Baker, F. and R. Martin. 1939. Studies in the microbiology of the caecum of the horse. Zentral. Fur Bakteriol. 99:400.

Bentley, O. G., R. R. Johnson, S. Vanecko and C. H. Hunt. 1954. Studies on factors needed by rumen micro-organisms for cellulose digestion *in vitro*. J. Animal Sci. 13:581.

Bulen, W. A., J. E. Varner and R. C. Burrell. 1952. Separation of organic acids from plant tissues. Anal. Chem. 24:187.

Crampton, E. W. and L. A. Maynard. 1938. The relation of cellulose and lignin content to the nutritive value of animal feeds. J. Nutr. 15:383.

Dehority, B. A., O. G. Bentley, R. R. Johnson and A. L. Moxon. 1957. Isolation and identification of compounds from autolyzed yeast, alfalfa meal and casein hydrolysate with cellulolytic factor activity for rumen micro-organisms *in vitro*. J. Animal Sci. 16:502.

Dehority, B. A., K. el-Shazly and R. R. Johnson. 1960. Studies on the cellulolytic fraction of rumen bacteria obtained by differential centrifugation. J. Animal Sci. 19:1098.

Hershberger, T. V., T. A. Long, E. W. Hartsook and R. W. Swift. 1959. Use of the artificial rumen technique to estimate the nutritive value of forages. J. Animal Sci. 18:770.

Johnson, R. R., Burk A. Dehority and O. G. Bentley. 1958. Studies on the *in vitro* rumen procedure; improved inoculum preparation and the effects of volatile fatty acids on cellulose digestion. J. Animal Sci. 17:481.

Linke, F. G. 1952. Chromatographic separation of volatile fatty acids produced in the artificial rumen. M.S. Thesis. The Ohio State University, Columbus, Ohio.

Moir, R. J. and Masson, M. J. 1952. An illustrated scheme for the microscopic identification of the rumen micro-organisms of sheep. J. Path. Bact. 64:343.

Quicke, G. V., O. G. Bentley, H. W. Scott and A. L. Moxon. 1959. Cellulose digestion *in vitro* as a measure of the digestibility of forage cellulose in ruminants. J. Animal Sci. 18:275.

Sijpesteijn, A. K. 1948. Cellulose decomposing bacteria from the rumen of cattle. Ph.D. Thesis. Leiden.

Warner, A. C. I. 1956. Criteria for establishing the valdity of *in vitro* studies with rumen micro-organisms in so-called artificial rumen systems. J. Gen. Microbiol. 14:733.

EFFECT OF CHLORTETRACYCLINE ON METHEMOGLOBINEMIA RESULTING FROM THE INGESTION OF SODIUM NITRATE BY RUMINANTS [1]

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MANY kinds of plants are now known to accumulate nitrates to the extent that they are potentially toxic (Gilbert *et al.*, 1946; Whitehead and Moxon, 1952), among them are some of our most popular forages. While feeds high in nitrates can be identified by chemical analysis, this has not proved to be an adequate control measure. A reduction of nitrate to nitrite and absorption of the latter into the circulatory system of an animal has been commonly recognized as being responsible for the methemoglobinemia of nitrate poisoning. The *in vitro* work of Sapiro *et al.* (1949) and Lewis (1951b), as well as the *in vivo* work of Lewis (1951a), has shown that a reduction of nitrate to nitrite occurs in the rumen. It appeared therefore that the feeding of an antibiotic might bring about microbial changes in the rumen that would either cause a decreased rate of conversion of nitrate to nitrite or an increased rate of reduction of the nitrite formed, thereby reducing the possibility of intoxication by forages of high nitrate content.

The experiments described here deal with the effect of chlortetracycline on the reduction of nitrate in the artificial rumen and on the formation of methemoglobin in sheep and cattle fed rations containing added nitrate.

Experimental Procedure

In Vitro Rumen Fermentation Studies. Incubation medium consisting of 80 ml. of strained, sheep rumen juice, 100 mg. dextrose and 30 mg. of nitrate nitrogen (added as $NaNO_3$) per 100 ml. was incubated with levels of chlortetracycline ranging from 0 to 2 ppm. Incubation was carried out at 39° C. in an atmosphere of CO_2 for 6 hours. After completion of the incubation period, fermentation was terminated by the addition of 20 ml. of a saturated solution of lead acetate. Nitrite was determined colormetrically by an adaptation of the alphanaphthylamine method (American Public Health Association, 1936). Nitrate plus nitrite was determined by a modification of the Devarda alloy reduction method (Olson and Whitehead, 1940).

In Vivo Study—Cattle. Eight grade Hereford cattle averaging 541 lb. were divided into four pairs and carried through four treatment periods. The rations presented in table 1 were assigned according to the latin square design shown in table 2. The concentrate portion of the rations was fed with ground alfalfa hay in the proportion of 2:1, resulting in a total sodium nitrate content of 2% in the high-nitrate rations and a chlortetracycline content of 10 mg. per lb. of feed for the rations containing the antibiotic. The rations were fed in approximately equal quantities with the amount limited to that normally cleaned up by most of the cattle. This approximated 13.2 lb. per animal per day. The feeding of nitrate salts with forages in a short-term experiment was shown by Crawford (1960) to produce a degree of methemoglobinemia similar to that obtained by the feeding of forages naturally high in nitrates.

One of the cattle in pair A developed urinary calculi early in the first treatment period and was removed from the experiment. Each treatment period was of 2 weeks duration and was followed by a 2-week readjustment period during which the basal ration was fed to all of the cattle. In this manner each of the cattle eventually served 2 weeks on each of the experimental rations. Methemoglobin was determined by the method of Evelyn and Malloy (1938) three times weekly using citrated blood.

In Vivo Study—Sheep. The concentrate portion of the rations shown in table 1 was fed with ground alfalfa hay in the proportion

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TABLE 1. CONCENTRATE PORTION OF RATIONS FED TO CATTLE AND SHEEP [a]

Ingredient	Cattle rations				Sheep rations			
	Basal	Basal+ Nitrate	Basal+ Chlortet-racycline	Basal+ Nitrate+ Chlortet-racycline	Basal	Basal+ Nitrate	Basal+ Chlortet-racycline	Basal+ Nitrate+ Chlortet-racycline
Ground corn, %	93	90	92.85	89.85	50	47	49.9	46.9
Ground oats, %	..	..	.....	.....	50	47	49.9	46.9
Soybean oil meal, %	5	5	5	5	..	..	....	....
Trace-mineralized salt, %	1	1	1	1	free choice			
Bone meal, %	1	1	1	1	free choice			
Sodium nitrate, %	..	3	.....	3	..	6	...	6
Aurofac 10, % [b]	..	..	0.15	0.15	..	..	0.2	0.2

[a] Concentrate portion of the rations was fed with ground alfalfa hay in the proportion of 2:1 for cattle and 1:1 for sheep.
[b] Aurofac 10 contains 10 gm. of chlortetracycline per pound.

of 1:1 to four groups of eight lambs each (av. wt.=58 lb.). The high-nitrate rations thus contained a total of 3% sodium nitrate, and the antibiotic rations contained 10 mg. of chlortetracycline per lb. The rations were fed in equal quantities with the amount limited to that which would normally be cleaned up by all of the groups. This amount averaged 2.1 lb. per sheep per day and was adequate to produce the following weight gains having no significant differences: basal, 15.7 lb.; basal + nitrate, 11.5 lb.; basal + chlortetracycline, 12.3 lb.; basal + nitrate + chlortetracycline, 14.2 lb.

Individual methemoglobin values were determined weekly during the 42-day experimental period using the method described for cattle.

Results and Discussion

Before the turn of the century, forage having a high nitrate content was reported to have caused livestock losses (Mayo, 1895, 1896; Pease, 1897). Later, "oat hay poisoning", reported by Newsom *et al.* (1937), was found to result in the formation of a high level of methemoglobin in cattle (Bradley *et al.*, 1939a) and was subsequently shown to be the result of excessive amounts of nitrate in the oat forage (Bradley *et al.*, 1939b). Bradley *et al.*, (1939b, 1940) also demonstrated that potassium nitrate isolated in crystalline form from toxic oat hay, and the pure salt itself, when administered to cattle, produced methemoglobinemia and symptoms the same as those for "oat hay poisoning". These workers recognized that methemoglobin formation was the result of the reduction of some of the nitrates to nitrite. They concluded from their studies (Bradley *et al.*, 1940; Gilbert *et al.*, 1946) that, although damp forages have been shown to be involved in some of the losses reported (Thorp, 1938), and although bacterial reduction of nitrate to nitrite in moist feeds

TABLE 2. ORDER OF FEEDING RATIONS TO FOUR PAIRS OF CATTLE

Cattle pair	Treatment period [a]			
	1	2	3	4
A	Basal+ Nitrate+ Chlortetracycline	Basal+ Chlortetracycline	Basal+ Nitrate	Basal
B	Basal	Basal+ Nitrate+ Chlortetracycline	Basal+ Chlortetracycline	Basal+ Nitrate
C	Basal+ Nitrate	Basal	Basal+ Nitrate+ Chlortetracycline	Basal+ Chlortetracycline
D	Basal+ Chlortetracycline	Basal+ Nitrate	Basal	Basal+ Nitrate+ Chlortetracycline

[a] Treatment periods were of 2 weeks duration with a 2-week readjustment period (basal diet was fed) allowed between each.

TABLE 3. THE EFFECT OF CHLORTETRACYCLINE ON NITRATE REDUCTION IN THE ARTIFICIAL RUMEN

Chlortetracycline	Average NO_2 N accumulated in 6 hr.	Average NO_3 N reduced in 6 hr.[a]	
ppm	mg.	mg.	%
0	1.62	19.2	64
0.5	0.30	17.2	57
1.0	0	16.2	54
1.5	0	15.4	51
2.0	0	14.4	48

[a] Indicates the amount of nitrate nitrogen that was reduced past the nitrite stage. Original concentration of NO_3 N in the incubation mixture was 30 mg. per 100 ml.

has been shown to occur under certain conditions (Olson and Moxon, 1942), the nitrate reduction in cases of poisoning was most likely to have taken place in the rumen.

Results obtained with the artificial rumen (table 3) show that 0.5 ppm of chlortetracycline greatly reduced the accumulation of nitrite nitrogen during a 6-hour incubation period, while 1 ppm and higher completely prevented nitrite accumulation. The amount of nitrate that was reduced during the incubation period became gradually less as the level of chlortetracycline was increased. This decreased reduction of nitrate is believed to be due to a general inhibition of microbial growth. However, this has not been verified.

The lower levels of chlortetracycline (0.5 to 1.0 ppm) that proved to be effective in preventing nitrite accumulation in the artificial rumen compares favorably with the amount estimated on the basis of rumen capacity to occur *in vivo* in the rumen of animals consuming a full-fed ration containing 10 mg. of chlortetracycline per lb. of feed.

High-nitrate rations containing 10 mg. chlortetracycline per lb. of feed, when fed to cattle under the conditions of this experiment, resulted in an average methemoglobin value 31.5% below that found in cattle receiving a similar ration without chlortetracycline (table 4). This difference was not statistically significant. With one exception, however, each of the cattle developed a less severe methemoglobinemia while fed the high-nitrate chlortetracycline ration than when fed the corresponding ration without the antibiotic.

Results obtained with sheep in a continuous feeding experiment are shown graphically in figure 1. The feeding of chlortetracycline to sheep lowered significantly the amount of methemoglobin formed during the first week of the high-nitrate feeding regime ($P<0.05$). The average methemoglobin level in this instance was less than one-half the magnitude of that obtained in the absence of the antibiotic. A trend toward lower methemoglobin values for the antibiotic-fed lambs remained during the second week. During the third and fourth weeks of the experiment, however, the situation was essentially reversed (fourth week significant at $P<0.01$) and the antibiotic-fed lambs reached peak methemoglobin levels that exceeded those previously attained in the absence of the antibiotic (figure 1). A marked decline in methemoglobin values occurred after the fourth week. This lack of a constant response of animals receiving a uniform level of nitrate over a period of several weeks is in agreement with previous observations (unpublished data, this laboratory) which showed that periods of severe methemoglobinemia often occur alternately with periods of moderation.

The data pertaining to antibiotic supplementation indicate that, although the time required for attainment of peak methemoglobin levels was increased, chlortetracycline did not appear to have an effect on the levels to be ultimately reached. These data are in agreement with the results obtained by Evans

TABLE 4. EFFECT OF NITRATE AND/OR CHLORTETRACYCLINE ON AVERAGE METHEMOGLOBIN LEVELS[a] IN CATTLE DURING 2-WEEK TREATMENT PERIODS

Animal number	Basal	Basal+ Chlortetracycline	Basal+Nitrate	Basal+Nitrate+ Chlortetracycline
1	.15	.14	1.51	.43
2	.12	.20	.27	.23
3	.14	.13	.68	.46
4	.24	.13	1.64	1.03
5	.22	.15	.83	2.28
6	.14	.15	1.52	.71
7	.18	.22	2.45	.96
Average	.17	.16	1.27	.87

[a] gm /100 ml. blood.

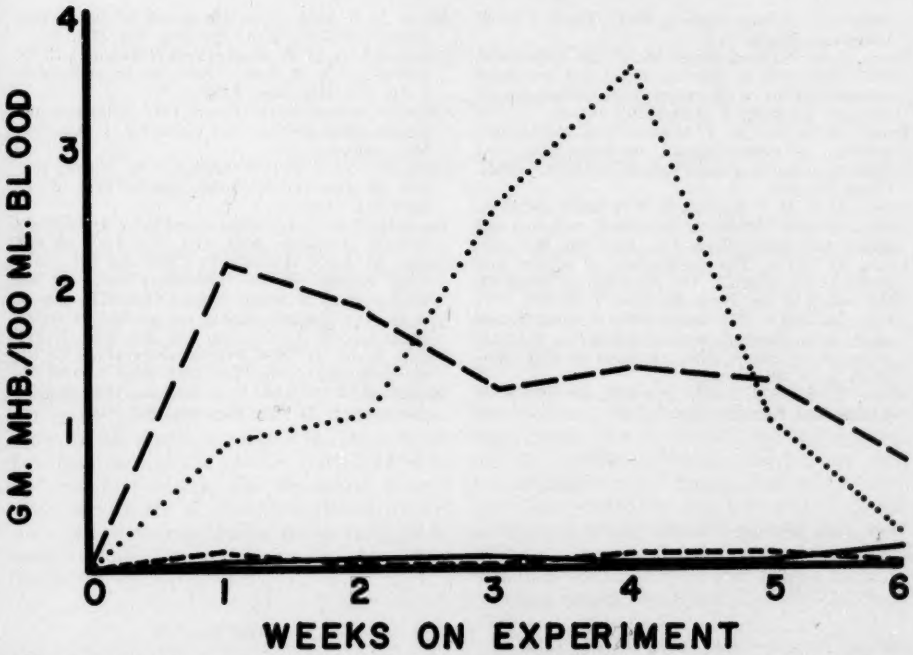

Figure 1. Effect of chlortetracycline on methemoglobin formation in sheep. Basal ration ————, basal + nitrate —— —— ——, basal + chlortetracycline — — — — — —, basal + nitrate + chlortetracycline .....

et al. (1957), which indicate that an eventual adjustment of rumen microorganisms to antibiotic supplementation occurs.

The effectiveness of the antibiotic supplementation for only 2 weeks of the 6-week sheep experiment suggest that the experiment utilizing cattle for only 2-week feeding periods did not allow time for adjustment of rumen microorganisms to the antibiotic supplement. In view of the temporary nature of the protection afforded by the antibiotic, it was felt that a need for further extension of the cattle work using only chlortetracycline was not indicated. However, the possibility of other antibiotics affording a more lasting protection should be given consideration in future experiments.

Summary

In vitro fermentation data obtained by use of an artificial rumen technique showed that 0.5 to 1.0 ppm of chlortetracycline was sufficient to suppress nitrate reduction and subsequent nitrite accumulation. Chlortetracycline fed at the rate of 10 mg. per lb. of feed was partially effective in retarding methemoglobin formation in cattle receiving high-nitrate rations for 2-week periods. When fed to sheep for longer periods, however, chlortetracycline provided partial protection only during the first 2 weeks of the 6-week experimental period. Thus, feeding 10 mg. of chlortetracycline per lb. of feed, although offering some protection at the onset against the methemoglobinemia resulting from the ingestion of rations high in nitrates, did not provide continuous protection.

Literature Cited

American Public Health Association. 1936. Standard Methods of Water Analysis (8th ed.). Lancaster Press, Inc., Lancaster.

Bradley, W. B., O. A. Beath and H. F. Eppson. 1939a. Oat hay poisoning. Science 89:365.

Bradley, W. B., H. F. Eppson and O. A. Beath. 1939b. Nitrate as the cause of oat hay poisoning. J. Am. Vet. Med. Assn. 94:541.

Bradley, W. B., H. F. Eppson and O. A. Beath. 1940. Livestock poisoning by oat hay and other plants containing nitrate. Wyo. Agr. Exp. Sta. Bul. 241.

Crawford, R. F. 1960. Some effects of nitrates in

forage on ruminant animals. Ph.D. Thesis. Cornell University, Ithaca, N. Y.

Evans, J. L., R. B. Grainger and C. M. Thompson. 1957. The effect of different levels and prolonged supplementation of chlortetracycline upon roughage digestion by sheep. J. Animal Sci. 16:110.

Evelyn, K. A. and H. T. Malloy. 1938. Microdetermination of oxyhemoglobin, methemoglobin, and sulfhemoglobin in a single sample of blood. J. Biol. Chem. 126:655.

Gilbert, C. S., H. F. Eppson, W. B. Bradley and O. A. Beath. 1946. Nitrate accumulation in cultivated plants and weeds. Wyo. Agr. Exp. Sta. Bul. 277.

Lewis, D. 1951a. The metabolism of nitrate and nitrite in the sheep. I. The reduction of nitrate in the rumen of the sheep. Biochem. J. 48:175.

Lewis, D. 1951b. The metabolism of nitrate and nitrite in the sheep. II. Hydrogen donators in nitrate reduction by rumen microorganisms *in vitro*. Biochem. J. 49:149.

Mayo, N. S. 1895. Cattle poisoning by nitrate of potash. Kan. Agr. Exp. Sta. Bul. 49.

Mayo, N. S. 1896. Cornstalk disease of cattle. Preliminary Bulletin, Kan. Agr. Exp. Sta. Bul. 58.

Newsom, I. E., E. N. Stout, Frank Thorp, Jr., C. W. Barber and A. H. Groth. 1937. Oat hay poisoning. J. Am. Vet. Med. Assn. 90:66.

Olson, O. E. and A. L. Moxon. 1942. Nitrate reduction in relation to oat hay poisoning. J. Am. Vet. Med. Assn. 100:403.

Olson, O. E. and E. I. Whitehead. 1940. Nitrate content of some South Dakota plants. Proc. S. D. Acad. Sci. 20:95.

Pease, H. T. 1897. Poisoning of cattle by *Andropogon Sorgum*. J. Comp. Med. and Vet. Arch. 18:679.

Sapiro, M. L., S. Hoflund, R. Clark and J. I. Quin. 1949. Studies on the alimentary tract of the Merino sheep in South Africa. XVI.—The fate of nitrate in ruminal ingesta as studied *in vitro*. Onderstepoort J. Vet. Sci. and An. Ind. 22:357.

Thorp, Frank, Jr. 1938. Further observations on oat hay poisoning. J. Am. Vet. Med. Assn. 92:159.

Whitehead, E. I. and A. L. Moxon. 1952. Nitrate poisoning. S. D. Agr. Exp. Sta. Bul. 424.

GENETIC ANALYSIS OF CROSSBREEDING BEEF CATTLE [1]

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RESULTS of an experiment designed to evaluate breeds of beef cattle in the Gulf Coast Region have been presented in previous papers (Damon *et al.*, 1959a,b, 1960). These papers were concerned with the pre-weaning and post-weaning performance of the various kinds of cattle produced and also with the carcass characteristics of the steers. The present paper is concerned with the genetic aspects of the study and presents estimates of heterosis, general and specific combining ability, maternal effects, and sex-linked effects. Since two of the six breeds included in the study were represented by males only, estimates of the genetic effects for these two breeds were not possible.

Experimental

The data on which this study was based resulted from a crossbreeding experiment initiated by Louisiana State University in 1951. At that time, six herds of 32 cows were formed. Each of these herds was composed of eight cows from each of the breeds: Angus, Brahman, Brangus, and Hereford. The Brangus cattle were loaned to the station by the Iberia Livestock Experiment Farm in Jeanerette, Louisiana and were treated in this project as a pure breed of cattle. It is estimated that these cattle averaged three-eighths Brahman and five-eighths Angus. The Angus and Hereford cattle consisted of both grade and purebred, while the Brahman cattle were all purebred. Each of the six herds was bred to one of the six breeds of bulls used in this experiment. The six breeds of bulls were Angus, Brahman, Brangus, Charolaise, Hereford, and Shorthorn. Replacements were necessary in each of the cow herds throughout the course of the experiment due to losses from death, disease, or reproductive failure. New bulls were selected each year and the cow herds rotated to a bull of a different breed in each of the five years during which this phase of the experiment was conducted. The females produced in this study were retained to be used in back-crosses and three-breed-crosses, the continuing phases of this experiment. The steers were retained and fed out on a wheat and rye grass pasture with a concentrate supplement, after which they were slaughtered in the University's Meats Laboratory where detailed carcass data were collected. Further details and results of the first phase of this experiment can be found in previous papers by Damon *et al.* (1959a,b, 1960).

A total of 597 calves were weaned for the 5-year period, of which 275 were steers. Table 1 shows the distribution of number of calves per subclass for both the number of calves weaned and the number of steers fed out. The breed groups have been separated into two sets, for purposes of this analysis, on the basis of whether females of the breeds were included in the study.

The data were analyzed by the method of fitting constants in a least-squares analysis. The methods of analysis for this type of data presented by Henderson (1948, 1952), with extensions for these specific data, were utilized. The model used to analyze the data was:

$$y_{hijkno}=\mu+t_h+q_i+v_{1j}+p_{11kk}+g_{\cdot 2n}+g_{\cdot 2k}+s_{12kn}+r_{12kn}+m_{\cdot 2k}+a_{22n}+c_{22k5}+c_{22k6}+e_{hijkno}$$

y_{hijkno} designates a measurement on the o^{th} progeny of a mating between a male of the n^{th} breed and a female of the k^{th} breed in the h^{th} year.

μ is an effect common to all animals.

t_h is an effect common to all animals born in the h^{th} year.

q_i is an effect common to all animals in i^{th} set of breed groups. The first set of breed groups is made up of the 16 groups having Angus, Brahman, Brangus, and Hereford

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TABLE 1. TABLE OF SUBCLASS NUMBERS

Line of dam	Line of sire													
	Angus		Brahman		Brangus		Hereford		Charolaise		Shorthorn		Totals	
	(c)[a]	(s)[b]	(c)	(s)	(c)	(s)	(c)	(s)	(c)	(s)	(c)	(s)	(c)	(s)
Angus	27	10	16	11	19	9	27	11	25	10	31	16	145	67
Brahman	29	18	23	10	22	13	29	13	24	8	23	8	150	70
Brangus	28	10	28	10	24	10	30	12	29	15	24	14	163	71
Hereford	26	11	21	11	21	11	27	11	23	11	21	12	139	67
Totals	110	49	88	42	86	43	113	47	101	44	99	50	597	275

[a] Column c indicates the number of calves weaned.
[b] Column s indicates the number of steers fed out.

sires. The second set is made up of the eight groups having Charolaise and Shorthorn sires.

v_{1j} is an effect common to the j^{th} type of breeding in the first set of breed groups, where the first type of breeding is purebred and the second type of breeding is crossbred. This is a measure of heterosis and as such is a comparison of the four purebred groups with the 12 crossbred groups.

p_{11kk} is an effect common to all animals in the purebred group sired by the k^{th} breed of sire and out of the k^{th} breed of dam. Estimation of these effects allows comparisons to be made among four breed groups.

$g_{\cdot 2k}$ ($g_{\cdot 2n}$) is an effect common to all animals of the k^{th} (n^{th}) breed. This is the general combining ability effect and is assumed to be one-half the additive genetic value of the k^{th} (n^{th}) breed. The 12 crossbred groups in the first set of breed groups as well as the eight crossbred groups in the second set of breed groups were used in estimating the additive genetic effects in this analysis.

s_{12kn} is an effect common to all animals resulting from matings of the k^{th} breed of dam by the n^{th} breed of sire and the n^{th} breed of dam by the k^{th} breed of sire. This is the specific combining ability effect and is a result of either dominance or epistasis or a combination of the two. It is a measure of how much better or poorer are the progeny of the mean of matings of k x n and n x k than would be expected on the basis of exact knowledge of the additive genetic values and maternal values of the breeds. The specific combining ability effects were measured in the 12 crossbred groups in the first set of breed groups.

r_{12kn} is an effect common to all animals resulting from matings of the k^{th} breed of dam by the n^{th} breed of sire. This is the sex-linked effect and measures the difference between reciprocal crosses after account has been taken of the difference in maternal ability between the k^{th} breed and the n^{th} breed. These effects were measured also in the 12 crossbred groups in the first set of breed groups.

$m_{\cdot 2k}$ is an effect common to all animals born from females of k^{th} breed. This is the maternal ability effect and is a measure of both pre-natal and post-natal ability. This is a function of the genotype of the breed rather than of genes transmitted to the progeny of females of the breed. Since each breed is used as the male and the female parent the maternal effect can be estimated by a comparison of each breed with respect to these two characteristics. All breed groups were used to estimate maternal effects with the exception of the purebred groups.

a_{22n} is an effect common to all animals having the n^{th} breed of sire in the second set of breed groups. Estimates of these effects provide a comparison of the animals sired by the two breeds of bulls represented in the second set of breed groups.

c_{22k5} is an effect common to all animals having the 5^{th} breed of sire and the k^{th} breed of dam. Estimates of these effects allow comparisons to be made among the crosses in this sire group.

c_{22k6} is an effect common to all animals having the 6^{th} breed of sire and the k^{th} breed of dam. Estimates of these effects allow comparisons to be made among the crosses in this sire group.

e_{hijkno} is the random error.

This model assumes that the interaction of years with the other effects in the model is not significant. However, the interaction of years with breed groups was tested for significance for each trait and found to be non-significant.

As pointed out by Henderson (1948), there are four rather unusual features inherent in the single-cross model. These features are (1) each experimental unit has in it two different

TABLE 2. DEGREES OF FREEDOM IN SINGLE-CROSS DATA FROM P BREEDS

Source of variation	Degrees of freedom
General combining ability	$p-1$
Specific combining ability	$\frac{p(p-3)}{2}$
Sex-linked effects	$\frac{p(p-3)}{2}+1$
Maternal ability	$p-1$

g_k, (2) the interaction effect, s_{kn}, has interchangeable subscripts, (3) g_k and m_k always go together, and (4) r_{kn} is always accompanied by s_{kn}.

In general, the degrees of freedom for general combining ability, specific combining ability, sex-linked effects, and maternal ability may be calculated from table 2, where p represents the number of breeds, from which p(p-1) reciprocal crosses are possible. Since no Charolaise or Shorthorn females were included in this experiment, the degrees of freedom were calculated from table 2 where $p=4$.

The traits included in this study were 180-day weight, slaughter calf grade, slaughter grade, rate of gain on feed, and weight per day of age. Slaughter grade, rate of gain on feed, and weight per day of age were measured on steers only.

Results and Discussion

The results of the analyses of the five traits considered in this paper are presented in table 3, 4, 5. The 180-day weights have been adjusted for both age of dam and sex of calf, the adjustment factors having been discussed in a previous paper (Damon *et al.*, 1959a). No adjustments were applied to the other four traits prior to the analysis. The slaughter grades were obtained at the close of the feeding period immediately before slaughter. Weights per day of age were based on weights at the close of the feeding period.

Years. A large amount of variation was encountered in the yearly means for the five traits, as shown by the constants presented in table 4. The analyses of variance shown in table 3 indicated that the yearly differences were highly significant for all traits. Since the crosses were produced by different sires and dams each year, part of the yearly differences were derived from this source. While there was a large disproportionality of subclass numbers from year to year, this was taken into account in the least-squares analysis so that the year effects should be unbiased. The variation in climatic conditions was marked, and the effect on calves produced in 1957 was particularly noticeable, with a great deal of rain and cold weather affecting these calves both pre- and post-weaning.

Breed Group Sets. The second set of breed groups was included in this analysis as it was possible to utilize them in estimating the general combining ability and maternal effects. This set of crosses does not contain any purebreds and therefore should have an advantage over the first set of crosses if hybrid vigor is of consequence. There is, thus, a confounding of additive and nonadditive gene effects

TABLE 3. ANALYSES OF VARIANCE FOR 180-DAY WEIGHT, SLAUGHTER CALF GRADE, SLAUGHTER GRADE, RATE OF GAIN, AND WEIGHT PER DAY OF AGE

		Mean squares					
Source of variation	d.f.	180-day weight	Slaughter calf grade	d.f.	Slaughter grade	Rate of gain	Weight per day of age
Years	4	10512**	297.4**	4	45.0*	.785*	.358**
First vs. second set of breed groups	1	57576**	.1	1	4.7	1.106**	.621**
Heterosis	1	21148**	2.5	1	10.6*	.717**	.414**
Among purebreds	3	17600**	9.5*	3	14.1**	.771	.056
General combining ability	3	32419**	34.0**	3	17.2**	.209	.246**
Specific combining ability	2	15512**	5.7	2	4.4*	.495*	.280**
Sex-linked effects	3	907	.1	3	2.1	.078	.046
Maternal effects	3	33246**	57.4**	3	3.0	.275	.129**
Charolaise vs. Shorthorn crosses	1	47251**	7.6	1	36.8**	.011	.071
Among Charolaise crosses	3	2987	5.6	3	3.3	.191*	.022
Among Shorthorn crosses	3	6852*	3.4	3	3.3	.080	.050
Error	569	2399	3.4	247	2.1	.062	.030

* $P<.05$.
** $P<.01$.

TABLE 4. TABLE OF CONSTANTS FOR YEARS, SETS OF BREED GROUPS, HETEROSIS, PUREBREDS, GENERAL COMBINING ABILITY, AND SPECIFIC COMBINING ABILITY

	180-day weight, lb.	Slaughter calf grade[a]	Slaughter grade[a]	Rate of gain, lb.	Weight per day of age, lb.
Over-all mean	421.53	11.89	10.57	1.73	1.77
Year					
1953	−2.15	1.85	−.39	−.04	−.01
1954	9.65	1.55	0.31	−.03	0.05
1955	6.88	−1.33	0.48	0.17	0.02
1956	−.24	−.53	0.97	0.05	0.08
1957	−14.14	−1.54	−1.38	−.15	−.13
Breed group					
First set	−11.03	0.01	−.15	−.07	−.05
Second set	11.03	−.01	0.15	0.07	0.05
Heterosis					
Purebreds	−8.45	−.09	−.29	−.08	−.06
Crossbreds	8.45	0.09	0.29	0.08	0.06
Purebred					
Angus	−17.26	0.02	0.67	0.15	0.02
Brahman	−27.16	−.55	−.91	−.38	−.11
Brangus	31.40	−.32	−1.07	−.02	0.03
Hereford	13.02	0.85	1.30	0.25	−.06
General combining ability					
Angus	−27.37	−.33	−.12	−.01	−.09
Brahman	12.60	0.42	0.22	0.08	0.11
Brangus	−6.09	−.86	−.97	−.12	−.06
Hereford	20.86	0.77	0.87	0.04	0.05
Specific combining ability					
Angus–Brahman	8.56	0.27	0.34	0.08	0.07
Angus–Brangus	5.90	−.04	−.09	0.04	0.03
Angus–Hereford	−14.46	−.23	−.25	−.12	−.10
Brahman–Brangus	−14.46	−.23	−.25	−.12	−.10
Brahman–Hereford	5.90	−.04	−.09	0.04	0.03
Brangus–Hereford	8.56	0.27	0.34	0.08	0.07

[a] Grading system: 17–15, prime; 14–12, choice; 11–9, good; 8–6, commercial; 5–3, utility.

in a comparison of the two sets of breed groups. Since the bulls used in the second set of crosses were mated to the same breeds of cows used in the first set of crosses, they should also vary according to whether these bulls cross better or poorer with the same breeds of cows. Analyses of variance showed highly significant differences in 180-day weight, rate of gain, and weight per day of age in favor of the second group of crosses, while no significant differences were found in slaughter calf grade or slaughter grade.

Heterosis. One of the primary objectives in the initiation of this experiment was to determine whether hybrid vigor played an important role in crosses among breeds of beef cattle. Heterosis was measured in the first set of breed groups by comparing the four purebred groups with the 12 crossbred groups. It can be seen from table 4 that the constants were in favor of the crossbreds for all of the five traits that were considered, the differences being significant or highly significant with the exception of slaughter calf grade. Estimates of the amounts of heterosis to be expected in the specific crosses can be obtained from a comparison of the average of the purebreds with the average of the reciprocal crosses. These averages can be calculated from the least-squares means previously reported (Damon *et al.*, 1959a,b), or by reconstruction of the means from the constants obtained in this study. The least-squares means for the purebred groups would be determined from the following equation:

$$\bar{y}_{11kk}=\hat{\mu}+\hat{q}_1+\hat{h}_{11}+\hat{p}_{11kk} \qquad (1)$$

The least-squares means for the 12 crossbred groups in the first set of breed groups would be determined from:

$$\bar{y}_{12kn}=\hat{\mu}+\hat{q}_1+\hat{h}_{12}+\hat{g}_{\cdot 2k}+\hat{g}_{\cdot 2n}+\hat{m}_{\cdot 2k}+\hat{s}_{12kn}+\hat{r}_{12kn} \qquad (2)$$

While the estimates of heterosis are of interest, they do not indicate which breed or cross is best with respect to a given trait. Comparisons of the means of the different breed groups are possible as explained above for the five traits considered. The selection of a particular cross is necessarily a choice for the individual livestock producer, as the advantage or disadvantage of any one cross changes with the marketing plan of the producer. For example, the producer who plans to sell his calves as slaughter calves at weaning would not be likely to select the same cross as the producer who plans to sell his calves as feeder calves. Whatever the producer's objective may be, the results of this experiment indicate that many of the crosses produced would be superior to any of the pure breeds for commercial production.

Crosses of inbred lines of rats by Kidwell *et al.* (1960) showed that heterosis had a significant effect on 70-day weight although the effect was not quite significant on 28-day weight. Chambers and Whatley (1951) also found in crossing lines of swine that hybrid vigor was demonstrated both in the number of pigs per litter and litter weight at birth, and increased as the litters became less dependent upon the direct mothering ability of the dams.

Purebreds. Analyses of variance for the five traits under consideration shown in table 3 revealed significant or highly significant differences among the breeds for all traits except weight per day of age. An examination of the constants in table 4 shows that while there were large differences among the groups, the breeds ranked differently for 180-day weight than they did for rate of gain. This resulted in a leveling out of differences in final weight and thus no significant differences were found in weight per day of age. The slaughter calf grades and the slaughter grades ranked the same and showed that the

TABLE 5. TABLE OF CONSTANTS FOR SEX-LINKED EFFECTS, MATERNAL EFFECTS, CHAROLAISE VS. SHORTHORN CROSSES, AMONG CHAROLAISE CROSSES, AND AMONG SHORTHORN CROSSES

	180-day weight, lb.	Slaughter calf grade[a]	Slaughter grade[a]	Rate of gain, lb.	Weight per day of age, lb.
Sex-linked effects					
Angus x Brahman[b]	−2.96	−.05	−.24	−.06	−.02
Angus x Brangus	0.07	0.02	0.35	0.07	0.05
Angus x Hereford	2.89	0.03	−.11	−.01	−.03
Brahman x Angus	2.96	0.04	0.24	0.06	0.02
Brahman x Brangus	2.35	−.02	−.31	−.04	0.00
Brahman x Hereford	−5.31	−.03	0.06	−.02	−.02
Brangus x Angus	−.07	−.02	−.35	−.07	−.05
Brangus x Brahman	−2.35	0.02	0.31	0.04	0.00
Brangus x Hereford	2.42	0.00	0.04	0.03	0.05
Hereford x Angus	−2.89	−.03	0.11	0.01	0.03
Hereford x Brahman	5.31	0.03	−.06	0.02	0.02
Hereford x Brangus	−2.42	0.00	−.04	−.03	−.05
Maternal effects					
Angus	15.57	0.32	0.16	0.02	0.05
Brahman	−7.82	−.36	−.26	−.11	−.09
Brangus	25.18	1.30	0.43	−.05	0.07
Hereford	−32.93	−1.26	−.33	0.14	−.03
Charolaise vs. Shorthorn crosses					
Charolaise crosses	15.57	−.20	−.66	−.01	0.03
Shorthorn crosses	−15.57	0.20	0.66	0.01	−.03
Charolaise crosses					
Charolaise x Angus	4.51	0.00	0.88	0.14	0.06
Charolaise x Brahman	13.95	0.75	−.76	−.24	−.07
Charolaise x Brangus	−.75	−.55	0.11	0.07	−.01
Charolaise x Hereford	−17.71	−.20	−.24	0.03	0.03
Shorthorn crosses					
Shorthorn x Angus	−14.86	−.23	−.70	−.02	−.05
Shorthorn x Brahman	27.88	0.64	0.15	−.10	0.05
Shorthorn x Brangus	0.24	−.32	0.71	0.14	0.08
Shorthorn x Hereford	−13.26	−.09	−.16	−.02	−.08

[a] Grading system: 17–15, prime; 14–12, choice; 11–9, good; 8–6, commercial; 5–3, utility.
[b] The sire is presented first.

British breeds received higher grades than the Brahman and Brangus breeds.

General Combining Ability. The constants for general combining ability indicated wide differences among the four breeds of cattle and the analyses of variance showed these differences to be highly significant. There was a high degree of consistency in the rankings, as the Hereford and Braham breeds ranked considerably higher than the Angus and Brangus breeds for all five traits which were considered. The wide difference indicated that these breeds do possess quite varied genetic potentials.

In a study of three-line crosses in swine, Magee and Hazel (1959), also found that differences in general combining ability were significant, although accounting for only 4% of the variation among pigs of the same season-farm group. Henderson (1949) found, in single crosses among 12 inbred lines of swine, that general combining ability accounted for not more than 5% of the variation among crosses for litter number and weight at 0, 21, 56, and 154 days. Kidwell *et al.* (1960) found that general combining ability effects were highly significant on body weight of rats at 28 days but not at 70 days. They hypothesized that preweaning differences in maternal ability and a post-weaning compensating effect might account for these results.

Specific Combining Ability. The estimates of the specific combining abilities of the pairs of reciprocal crosses showed that these effects were more important in the measurements of growth rate than in grades (table 5). Highly significant differences were found among the 180-day weight, rate of gain, and weight per day of age constants, while the differences were significant at the five percent level for slaughter grade. The constants show that the crosses involving the more widely divergent genetic sources such as the Hereford and Brahman breeds, yielded higher estimates of specific combining ability than crosses of more similar genetic material, such as the Angus and Hereford breeds. Since only two degrees of freedom were available for estimates of these effects (see table 2), only three different constants were obtained for the six crosses.

The importance of specific combining ability for most of the traits considered in this study is not in agreement with the results of Hetzer *et al.* (1961) who found little evidence of specific combining ability in crossing inbred lines of swine, or with Magee and Hazel (1959) who also found no significant effects of specific combining ability in three-line crosses of swine. However, Henderson (1949) found that specific effects accounted for 5 to 15% of the variation among single crosses of inbred lines of swine. An analysis by Bradford *et al.* (1958) of crosses among lines of swine showed no significant differences among estimates of specific combining ability, general combining ability, or maternal effects.

Sex-Linked Effects. The constants for sex-linked effects are presented in table 5 and show that sex-linkage apparently did not play a major role in causing differences in any of the five traits which were considered. The mean squares were all small and table 3 shows that there were no significant differences among the constants. Kidwell *et al.* (1960) also found no evidence of sex-linked effects in crossing inbred lines of rats and Henderson (1949) found that none of the variation among crosses of inbred lines of swine was caused by sex-linked effects.

Maternal Ability. The maternal ability of the cow is of great importance in the production of beef cattle, particularly in the southern region where a large number of calves are sold as slaughter calves at weaning. Highly significant differences were found in the maternal effects for 180-day weight, with a 58-lb. difference noted between the Brangus and Hereford dams. Since these effects are due primarily to the milking ability of the dam, it is quite clear that the Hereford cattle in this study were definitely deficient in this respect. The slaughter calf grade received by a calf is dependent to a large degree on the nutrition it has received prior to weaning and as such will be influenced by differences in maternal abilities of the dams. Highly significant differences were found in the maternal effects for slaughter calf grade, the ranking for the breeds being the same as for 180-day weight. The constants for slaughter grade were of the same ranking as the two previous traits but the differences among them were not significant. Highly significant differences were found for the maternal effects for rate of gain but in this case the ranking was different, showing higher values for the dams of British breeding. The constants for weight per day of age also showed highly significant differences, with the maternal effects for the Brangus and Angus dams being higher than those of the Hereford and Brahman.

Kidwell *et al.* (1960) also found highly sig-

nificant differences among maternal effects in crossing inbred lines of rats, although Henderson (1949) and Magee and Hazel (1959) reported no significant differences among maternal effects in crossing lines of swine.

It can be seen from table 6 that a high negative relationship exists between the estimates of maternal and general combining ability effects for four of the five traits. As pointed out by Magee and Hazel (1959) and Kidwell *et al.* (1960), a negative correlation is expected between these two estimates because of the confounding of the two effects, since the maternal effect of a line is measured by subtracting the sire effect from the dam effect. The expected correlations have been calculated from the elements of the matrix inverse and are shown in table 6. The observed correlations were calculated from the constants resulting from the analyses. The differences between the observed and expected correlations provide a limited amount of evidence concerning the genetic correlation of maternal and general combining ability.

The positive difference between the observed and expected correlation for the rate of gain on feed as compared with the negative difference for 180-day weight is in close agreement with the results of Kidwell *et al.* (1960) who found a difference of —.36 for weaning weights and a difference of 0.56 for weights 44 days after weaning in crossing inbred lines of rats.

Charolaise vs. Shorthorn Crosses. The analyses revealed that while the calves sired by Charolaise bulls attained significantly heavier weights than those sired by the Shorthorn bulls, there was no significant difference in slaughter calf grade. However, there was a significant difference in slaughter grade in favor of the steers sired by Shorthorn bulls. No significant difference was found in rate of gain on feed or weight per day of age.

Charolaise Crosses. The only significant difference found among the four Charolaise crosses was in rate of gain. This was due primarily to the low rate of gain on feed for the Charolaise x Brahman steers.

Shorthorn Crosses. Differences among the 180-day weights of the different groups of Shorthorn calves were significant mainly because of the greater weights attained by the Shorthorn x Brahman calves. No significant differences were found among the constants for the other traits.

It is possible to compare the least-squares means of the last eight crosses with the means of the first 16 groups by reconstruction of the subclass means for the last eight crosses with the following equation:

$$\bar{y}_{22kn}=\hat{\mu}+\hat{q}_2+\hat{a}_{22n}+\hat{g}_{\cdot 2k}+\hat{m}_{\cdot 2k}+\hat{c}_{22kn}$$

The model under which these data were analyzed permitted one degree of freedom in a measure of over-all heterosis and it was found that there was either a significant or highly significant effect of heterosis for all traits considered with the exception of slaughter calf grade. However, the amounts of heterosis exhibited by the particular crosses are of considerable importance and the estimates of these amounts are shown in table 7. The amount of heterosis displayed in each cross was tested for significance and the results of these tests are shown in the table. While these tests of significance are not independent since the purebreds are each used three times, they are of considerable interest. Tests of significance were also made among the amounts of heterosis shown by the different crosses by means of Duncan's (1955) multiple range test as extended by Kramer (1957) to give tests for differences among means with unequal replications. The results of these tests are presented in the lower portion of the table.

The data in table 7 show that, except for the Angus-Hereford cross, the reciprocals had heavier 180-day weights than did the parental breeds, with the Brahman-Hereford, Angus-Brahman, and Angus-Brangus crosses

TABLE 6. CORRELATION BETWEEN GENERAL COMBINING ABILITY AND MATERNAL EFFECTS

	180-day weight, lb.	Slaughter calf grade	Slaughter grade	Rate of gain on feed, lb.	Weight per day of age, lb.
Observed r	—.82	—.98	—.95	.09	—.97
Expected r	—.60	—.60	—.59	—.59	—.59
Difference	—.22	—.38	—.36	.68	—.38

TABLE 7. ESTIMATES OF HETEROSIS AND TESTS OF SIGNIFICANCE

180-day weight, lb.	Slaughter calf grade[a]	Slaughter grade[a]	Rate of gain, lb.	Weight per day of age, lb.
B–H[b, c] 42.95**	A–B 0.78*	B–H 1.09**	B–H 0.40**	B–H 0.26**
A–B 36.77**	B–BA 0.43	A–B 1.09**	A–B 0.37**	A–B 0.23**
A–BA 26.47**	B–H 0.38	BA–H 0.77**	B–BA 0.12*	BA–H 0.15**
B–BA 15.50	BA–H 0.12	B–BA 0.65*	BA–H 0.09	B–BA 0.09*
BA–H 14.15	A–BA 0.10	A–H 0.01	A–BA —.01	A–BA 0.03
A–H —10.62	A–H —.50	A–BA —.10	A–H —.05	A–H —.07*
(B–H, A–B, A–BA)[d] (A–B, A–BA, B–BA, BA–H) (B–BA, A–H)	(A–B, B–BA, B–H, BA–H, A–BA) (B–BA, B–H, BA–H, A–BA, A–H)	(B–H, A–B, BA–H, B–BA) (B–BA, A–H) (A–H, A–BA)	(B–H, A–B) (B–BA, BA–H) (BA–H, A–BA) (A–BA, A–H)	(B–H, A–B) (A–B, BA–H) (BA–H, B–BA) (B–BA, A–BA) (A–H)

* Significant at the 5% level.
** Significant at the 1% level.
[a] Grading system: 17–15, prime; 14–12, choice; 11–9, good; 8–6, commercial; 5–3, utility.
[b] The abbreviations used in this table are as follows: A=Angus; B=Brahman; BA=Brangus; C=Charolaise; H=Hereford; S=Shorthorn.
[c] The estimates of heterosis that are presented are contrasts of the reciprocal crosses with the corresponding two groups of straightbred cattle.
[d] The tests of significance are presented so that any two estimates of heterosis included by the same parentheses do not differ significantly, and any two estimates not included by the same parentheses do differ significantly ($P<.05$).

showing highly significant amounts of heterosis. A consideration of slaughter calf grade indicated that only the Angus-Brahman cross exhibited a significant amount of heterosis for this trait. The effects of heterosis were very pronounced for slaughter grade where four of the crosses demonstrated a significant or highly significant degree of heterosis. Three of the six crosses showed significant or highly significant amounts of heterosis for rate of gain on feed. Four of the six crosses exhibited significant or highly significant amounts of heterosis for weight per day of age, although in addition, the Angus-Hereford cross showed a significant degree of negative heterosis.

It can be seen that in general the greatest amounts of heterosis were demonstrated in crosses involving parental breeds of widely divergent sources such as the Brahman and Hereford breeds. With the sole exception of the slaughter calf grades received by the Brahman-Hereford calves, the Brahman-Hereford and the Brahman-Angus crosses yielded highly significant amounts of heterosis for all the five traits considered. However, the Angus-Hereford reciprocal crosses averaged lower than the parental breeds for four of the five traits, although significantly lower in only one case. The reason for the poor performance of these crosses is not known.

Since differences between maternal effects were large, a detailed study of reciprocal crosses would yield additional information with respect to breeding plans designed to take advantage of heterosis.

Importance of Effects. The importance of the general combining ability, maternal ability, and specific combining ability effects on the five traits under consideration can be seen from table 8. The general combining ability effects accounted for a considerable portion of the variance among crosses for all traits except rate of gain on feed, the percents ranging from 1.3 to 18.7. Maternal ability effects accounted for a larger percent of the variance among crosses for the preweaning traits of 180-day weight and slaughter calf grade than for the traits measured only on the steers. The values of 15% and 20% for 180-day weight and slaughter calf grade, respectively, emphasize the importance of the maternal ability prior to weaning. While the percents of the variance among crosses accounted for by specific combining ability effects were low for the traits of 180-

TABLE 8. PERCENT OF VARIANCE AMONG CROSSES ACCOUNTED FOR BY GENERAL COMBINING ABILITY, MATERNAL ABILITY, AND SPECIFIC COMBINING ABILITY

	180-day weight	Slaughter calf grade	Slaughter grade	Rate of gain	Weight per day of age
General combining ability	12.7%	9.8%	18.7%	1.3%	12.5%
Maternal ability	15.0%	20.0%	1.5%	10.3%	7.7%
Specific combining ability	7.5%	1.0%	3.9%	21.0%	27.4%

day weight, slaughter calf grade, and slaughter grade, these effects accounted for 21.0% and 27.4% of the variance among crosses for rate of gain and weight per day of age.

Summary and Conclusions

A genetic analysis was made of the data resulting from an experiment designed to evaluate breeds of beef cattle and crosses among breeds of beef cattle in the Gulf Coast Region. Six herds of cows were formed, each composed of eight cows from the Angus, Brahman, Brangus, and Hereford breeds. Each of these herds was bred to a bull of a different breed for five breeding seasons. The bulls used in this study were from the Angus, Brahman, Brangus, Charolaise, Hereford, and Shorthorn breeds. Data were available on 597 heifers and steers for 180-day weight and slaughter calf grade and on 275 steers for slaughter grade, rate of gain on feed, and weight per day of age.

A significant or highly significant heterosis effect was found for 180-day weight, slaughter grade, rate of gain on feed, and weight per day of age, but none for slaughter calf grade.

General combining ability effects were found to be significant for all five traits. These effects accounted for a considerable percent of the variance among crosses for all traits except rate of gain, the percents ranging from 1.3 to 18.7.

Specific combining ability effects were found to be significant or highly significant for all traits except slaughter calf grade. These effects were particularly important for rate of gain on feed and weight per day of age where they accounted for 21.0% and 27.4%, respectively, of the variance among crosses.

Maternal effects were found to be highly significant for all traits except slaughter grade. These effects were particularly important for 180-day weight where they accounted for 15% of the variance among crosses and for slaughter calf grade where they accounted for 20% of the variance.

Sex-linked effects appeared to have little if any influence on any of the five traits considered.

Even though dealing with limited numbers of breeds and animals, large differences were demonstrated among breeds and crosses of breeds in different types of gene action.

Literature Cited

Bradford, G. E., A. B. Chapman and R. H. Grummer. 1958. Effects of inbreeding, selection, linecrossing and topcrossing in swine. III. Predicting combining ability and general conclusions. J. Animal Sci. 17:456.

Chambers, Doyle and J. A. Whatley. 1951. Heterosis in crosses of inbred lines of Duroc Swine. J. Animal Sci. 10:505.

Damon, R. A., Jr., R. M. Crown, C. B. Singletary and S. E. McCraine. 1960. Carcass characteristics of purebred and crossbred beef steers in the Gulf Coast Region. J. Animal Sci. 19:820.

Damon, R. A., Jr., S. E. McCraine, R. M. Crown and C. B. Singletary. 1959a. Performance of crossbred beef cattle in the Gulf Coast Region. J. Animal Sci. 18:437.

Damon, R. A., Jr., S. E. McCraine, R. M. Crown and C. B. Singletary. 1959b. Gains and grades of beef steers in the Gulf Coast Region. J. Animal Sci. 18:1103.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics 11:1.

Henderson, C. R. 1948. Estimation of general, specific and maternal combining abilities in crosses among inbred lines of swine. Ph.D. Thesis. Iowa State College, Ames, Iowa.

Henderson, C. R. 1949. Estimation of general, specific, and maternal combining abilities in crosses among inbred lines of swine. J. Animal Sci. 8:606 (Abst.).

Henderson, C. R. 1952. Specific and general combining ability. Heterosis. Edited by John W. Gowen. Iowa State College Press. Ames, Iowa.

Hetzer, H. O., R. E. Comstock, J. H. Zeller, R. L. Hiner and W. R. Harvey. 1961. Combining abilities in crosses among six inbred lines of swine. U.S.D.A. Tech. Bul. 1237.

Kidwell, J. F., H. J. Weeth, W. R. Harvey, J. H. Haverland, C. E. Shelby and R. T. Clark. 1960. Heterosis in crosses of inbred lines of rats. Genetics. 45:225.

Kramer, C. Y. 1957. Extension of multiple range tests to group correlated adjusted means. Biometrics 13:13.

Magee, W. T. and L. N. Hazel. 1959. General and specific combining ability for 154-day weight among three-line crosses in swine. J. Animal Sci. 18:790.

EFFECT OF FEED INTAKE ON SEMEN CHARACTERISTICS AND REPRODUCTIVE PERFORMANCE OF MATURE BOARS [1, 2]

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THE relationship of nutrition to the reproductive capacity of the male of several species has received the attention of investigators for many years. In the early work, emphasis was placed on spermatogenic activity of the testes and little information was obtained on the function of accessory organs. More recently, chemical analyses of seminal plasma have shown that accessory organs are often more sensitive to nutritional deficiencies than are the testes (Mann, 1954). Some effects of restricted feed intake on young boars have been reported by Niwa (1954) and by Dutt and Barnhart (1959). Effects on semen characteristics of mature boars subjected to feed restriction sufficient to cause a marked loss of weight or overfed to produce obesity have not been studied.

This research was conducted to determine the effect of plane of nutrition on certain chemical and physical properties of semen and their relationship to reproductive performance of mature boars. It is anticipated that such information may be useful in feeding and management of boars in a stud maintained for artificial insemination.

Experimental Procedure

Six 22-month-old Yorkshire boars, which were from the same herd and known to be fertile, were assigned to three groups of two boars each. Weight of individual boars at the beginning of the test ranged from 445 to 555 lb. and averaged 495 lb. Group I received *ad libitum* the ration shown in table 1. The average daily consumption of 16 lb. of feed per head at the start of the experiment declined to 9 lb. per head by the end of 15 months. Group II was hand-fed 6.75 lb. of the same ration per head per day throughout the experiment. This amount was sufficient to meet 100% of the National Research Council (Beeson *et al.*, 1959) recommendations for adult boars. Group III was hand-fed 4.5 lb. of the ration per head per day during the first 6 months and 3.25 lb. per head daily for an additional 9.5 months. These amounts were equivalent in TDN to 75% and 50%, respectively, of the NRC recommendations for adult boars. Thus, a "normal" and two extreme levels of nutrition were employed. Each boar was housed individually in a 4.5 ft. x 15 ft. pen with a concrete floor. They did not have access to an outside run and the housing provided excellent protection from temperature extremes. Heating and cooling devices were not used at any time. Wood shavings were used for bedding, and the pens were cleaned daily.

Semen was collected twice weekly at 3- and 4-day intervals using an artificial vagina and a dummy sow. No attempt was made to measure libido. Ejaculate volume was measured immediately after collection and again following removal of the gelatinous material after straining through four layers of 44 x 36 mesh gauze.

Ratings on percent motility and type of motility of spermatozoa were made immediately after straining as described by Stratman *et al.* (1958). Spermatozoa concentrations were estimated with a hemocytometer on every ejaculate during the first six months and on alternate ejaculates thereafter. Samples for chemical analyses were taken from the strained ejaculate, placed in 10 ml. vials, labeled, frozen and stored at —10° F. until analyzed.

Body weight and backfat thickness of each boar were determined at regular intervals throughout the experimental period. Backfat was expressed as an average of probes taken 2 in. off the mid-line at approximately the

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TABLE 1. COMPOSITION OF RATION[a]

Ingredients	lb.
Ground yellow corn	320
Ground oats	480
Alfalfa meal, 17% protein	80
Soybean oil meal, 44% protein	60
Meatscraps, 50% protein	60
Trace mineralized salt	5
"Aurofac"	1
Zinc sulfate heptahydrate	0.5
Irradiated yeast	0.25
	1006.75

[a] Calculated percent crude protein, 15.7; percent TDN, 71.7; digestible energy, Cal./lb., 1425; Ca:P ratio, 1.35:1.

seventh rib and at the first or second lumbar vertebra.

Levels of citric acid, ergothioneine, fructose, and inositol were determined on semen from every other collection during the first 6 months and on every fourth collection thereafter. Protein nitrogen and non-protein nitrogen analyses were made throughout on every fourth collection. These constituents were studied, because they are among the major components of seminal plasma, and high levels of ergothioneine and of inositol are especially characteristic of boar semen.

Total nitrogen in the seminal plasma was determined by the semi-micro Kjeldahl method. Non-protein nitrogen was determined by a modification of the Nesslerization technique described by Johnson (1941) after the protein had been precipitated with tungstic acid by the Folin and Wu method (1919). Protein nitrogen was calculated as the difference between total nitrogen and non-protein nitrogen.

Citric acid was determined by the method of Saffran and Denstedt (1948) and ergothioneine by the method of Melville and Lubschez (1953). Fructose determinations were made by the method of Roe (1934) and inositol was measured by the microbiological method of Atkin *et al.* (1943), with the exception that sufficient yeast was used for the inoculum to give 20% light transmission rather than 20% absorption. Samples for inositol assay were prepared according to the method described by Halliday and Anderson (1955) using 2 ml. of strained semen and 10 ml. of 7.2 N H_2SO_4. The samples were placed in an autoclave overnight, neutralized to approximately pH 5.0 with calcium carbonate and filtered to remove the calcium sulfate. Because *Saccharomyces carlsbergensis* is inhibited by choline (Halliday, 1955), a constant amount of choline chloride was added to each sample sufficient to give a ratio of choline to inositol of between 45 and 90 to 1. A ratio of 60 to 1 was used for the inositol standard.

Fertilizing abilities of semen samples were determined at three- and four-month intervals throughout the experiment by inseminating gilts artificially with 2.5 x 10^9 cells in 50 ml. of seminal plasma. This volume was selected because of the observation that smaller volumes reduced conception rate and number of embryos present at the 25th day of gestation (Stratman and Self, 1960). The ejaculate was fractionated during collection into a pre-spermatozoa, a spermatozoa-rich, and a post-spermatozoa fraction. The volume of the spermatozoa-rich portion necessary to provide 2.5 x 10^9 spermatozoa was combined with sufficient spermatozoa-free seminal plasma to give a total volume of 50 ml. The spermatozoa-free material was prepared from the sample by centrifuging the pre- and post-spermatozoa fractions for 20 minutes at 2800 rpm. Semen was inseminated within an hour after collection.

Gilts used in the fertility studies were obtained from a local packing company and from the University of Wisconsin swine research and breeding herds. They were checked for heat once daily, allowed to proceed through at least one estrual cycle and were inseminated within 24 hours after being again detected in heat. They were slaughtered 23 to 28 days after breeding and the corpora lutea and embryos were counted. Gilts with abnormal reproductive tracts were not included in the data.

After 15½ months on experiment, the treatments for the limited- and the full-fed boars were reversed for a 10-week period (the second phase), and semen samples were collected and analyzed as previously described.

Results

During the 15½ months on the first phase of the experiment, the full-fed boars (Group I) gained an average of 300 lb., the medium-fed group (Group II) gained an average of 85 lb. and the limited-fed boars (Group III) lost an average of 132 lb. Average backfat thickness in Group I changed from 1.7 in. at the beginning of the experiment to 3.0 in., in Group II from 1.7 in. to 1.5 in., and in Group III from 1.4 in. to an amount too thin to detect. Limited-fed boar 190 lost over one-

third of his starting weight, was extremely emaciated and in a state of lethargy at the end of the first phase. The other limited-fed boar lost weight but more effectively maintained his strength. Both of the full-fed boars accumulated extremely large amounts of fat. Marked overfeeding, severe underfeeding and a "normal" level of feeding were, therefore, accomplished.

Libido was not consistently affected by treatment except in the 15th month, when both limited-fed boars refused to serve the artificial vagina at any time during a 2-week period.

tions were reported by Niwa and Mizuho (1954).

In table 2 are shown the average values for the semen characteristics for each treatment group, the range of values for individual ejaculates, and the number of samples analyzed.

The overall averages for volume of the ejaculate, volume of the strained ejaculate and spermatozoa concentration were 289 ml., 232 ml., and 220 x 10^6 per ml., respectively. The average total number of spermatozoa per ejaculate of 46 x 10^9 was not significantly affected by treatment except for a sharp de-

TABLE 2. AVERAGE VALUES PER EJACULATE FOR THE OBSERVED CHARACTERISTICS FOR THE 15½-MONTH FIRST PHASE

Characteristic	Plane of nutrition			Range
	Limited	Medium	Full	
Volume of ejaculate, ml.	219 (245) [a]	328 (247)	320 (258)	16–606
Volume of strained ejaculate, ml.	160 (239)	259 (237)	277 (247)	10–472
Spermatozoa concentration, 10^6/ml.	266 (168)	183 (170)	211 (172)	5–800
Spermatozoa per ejaculate, 10^9	41 (168)	43 (170)	55 (172)	2–218
Fructose concentration, mg./100 ml.	8.3 (77)	8.0 (73)	25.6 (78)	0.5–114
Fructose per ejaculate, mg.	19.1 (77)	19.0 (73)	85.5 (78)	0.4–449
Citric acid concentration, mg./100 ml.	116 (75)	101 (77)	146 (81)	32–375
Citric acid per ejaculate, mg.	240 (75)	271 (77)	444 (81)	29–1024
Inositol concentration, mg./100 ml.	239 (66)	264 (68)	354 (71)	8–880
Inositol per ejaculate, mg.	494 (66)	704 (68)	1049 (71)	10–2860
Ergothioneine concentration, mg./100 ml.	25.4 (71)	32.5 (67)	46.2 (76)	9–84
Ergothioneine per ejaculate, mg.	45 (71)	84 (67)	130 (76)	11–252
Protein nitrogen concentration, mg./100 ml.	230 (44)	221 (49)	371 (52)	15–636
Protein nitrogen per ejaculate, mg.	467 (44)	555 (49)	1102 (52)	32–2506
Non-protein nitrogen concentration, mg./100 ml.	37 (44)	35 (49)	39 (52)	17–58
Non-protein nitrogen per ejaculate, mg.	64 (44)	88 (49)	111 (52)	11–203
Conception, %	46.2 (39) [b]	48.8 (41)	48.8 (41)	.....
Corpora lutea represented by normal embryos in pregnant gilts, %	75.3	59.4	71.1	.....

[a] Number of samples analyzed.
[b] Number of gilts inseminated.

The average type and percent motility scores for the semen of all boars were 8 and 85, respectively. There was very little boar difference except for limited-fed boar 190, whose spermatozoa motility ratings dropped off rapidly during the final month of the 15½-month period. Abnormal spermatozoa appeared sporadically among several boars in the later stages of the experiment, but did not appear to be an effect of treatment.

As the experimental period progressed, seasonal variations in some characteristics became apparent. Spermatozoa concentration and total number of spermatozoa per ejaculate were highest during the warm months of June through August. In five of the six boars, the volume per ejaculate increased during the cool fall months. Similar observa-

crease in limited-fed boar 190 during the last 2 months of the first phase.

The average concentrations of citric acid, inositol, protein nitrogen and non-protein nitrogen per 100 ml. of semen were 121, 286, 284, and 37 mg., respectively, while the total amounts per ejaculate were 318, 749, 708, and 88 mg., respectively. Moderate variations in levels of various characteristics among ejaculates from the same boar were observed; however, there was a tendency for succeeding ejaculates to be relatively consistent. Wide variations in chemical composition of seminal plasma existed between boars on the same treatment. This was especially noticeable in the fructose data. Average concentration of fructose in the semen of all boars was 14 mg. per 100 ml., and total fructose per ejaculate

TABLE 3. TIME TRENDS AND MEAN VALUES OF EACH CHARACTERISTIC FOR THREE-MONTH PERIODS (ALTERNATE PERIODS OMITTED)

Characteristic	Period[a] and plane of nutrition								
	Limited			Medium			Full		
	1	3	5	1	3	5	1	3	5
Volume of ejaculate, ml.	316	185	146	310	335	303	330	289	333
Volume of strained ejaculate, ml.	234	136	100	238	266	238	292	245	280
Number of spermatozoa per ejaculate, 10^9	45.8	44.8	25.2	41.8	54.3	38.7	47.2	68.9	58.3
Citric acid concentration, mg./100 ml.	174	85	60	125	114	59	168	128	94
Fructose concentration, mg./100 ml.	19.8	2.9	3.8	12.5	7.8	4.4	25.3	12.2	26.1
Ergothioneine concentration, mg./100 ml.	32	15	28	40	31	31	54	50	36
Inositol concentration, mg./100 ml.	386	167	125	359	234	189	423	320	263
Protein nitrogen concentration, mg./100 ml.	384	143	150	296	222	153	395	364	290
Non-protein nitrogen concentration, mg./100 ml.	42	31	45	42	31	35	44	35	39
Conception, %	88	31	40	67	50	42	75	69	29
Corpora lutea represented by normal embryos in pregnant gilts, %	73	81	73	90	51	52	88	70	64

[a] Period 1—Dec. 1, 1958 to Feb. 28, 1959.
Period 3—June 1, 1959 to Aug. 31, 1959.
Period 5—Dec. 1, 1959 to Feb. 29, 1960.

was 41 mg. One full-fed boar, 180, consistently produced semen with 40 mg. per 100 ml. or more. This same boar, while not producing the largest volume of semen, produced the highest levels of inositol, citric acid, protein nitrogen, ergothioneine, and total spermatozoa numbers.

In table 3 are shown average values of some of the studied characteristics during 3-month alternating periods. The wide variation among treatment groups can be readily observed.

The data were analyzed statistically by determining linear regression coefficients (Steel and Torrie, 1960) between each characteristic and number of days on experiment for each boar. The regression coefficients for a given characteristic were pooled when the "t" test did not show a significant difference between the coefficients for the two boars from the same treatment (table 4). The regression coefficients for each boar are listed for the characteristics which could not be pooled. A criticism of this method of analysis is that a semen component such as ergothioneine, whose concentration apparently decreased markedly in the limited-fed group during the first few weeks of the experiment, may not be properly evaluated. Likewise, cyclic or seasonal changes are masked.

Regression coefficients for volume of the whole ejaculate, volume of the strained ejac-

TABLE 4. REGRESSION COEFFICIENTS BETWEEN EACH CHARACTERISTIC AND THE NUMBER OF DAYS ON EXPERIMENT—FIRST PHASE

Characteristic	Plane of nutrition and boar identification					
	Limited		Medium		Full	
	182	190	142	194	160	180
Total volume of ejaculate, ml./day	—.391***[a]		0.102		—.102**	0.115
Strained ejaculate volume, ml./day	—.307**		0.095		—.120**	0.077
Spermatozoa concentration, 10^6/ml./day	0.391**		—.070		0.091	
Spermatozoa per ejaculate, 10^6/day	0.020	—.061*	0.011		0.025	
Fructose concentration, mg./100 ml./day	—.051**		—.021		—.002	
Fructose per ejaculate, mg./day	—.142*		—.044		0.025	
Citric acid concentration, mg./100 ml./day	—.345**		—.191		—.213	
Citric acid per ejaculate, mg./day	—1.174**		—.386		—.557	
Inositol concentration, mg./100 ml./day	—.632*		—.463		—.451	
Inositol per ejaculate, mg./day	—2.059**		—.910		—1.257	
Ergothioneine concentration, mg./100 ml./day	—.040		—.037		—.056	
Ergothioneine per ejaculate, mg./day	—.113		—.031		—.203*	
Protein nitrogen concentration, mg./100 ml./day	—.578		—.408		—.446	
Protein nitrogen per ejaculate, mg./day	—1.845*		—.776		—.833	
Non-protein nitrogen concentration, mg./100 ml./day	0.006		—.013		—.007	
Non-protein nitrogen per ejaculate, mg./day	—.125**		0.016		—.042	

* Significantly different from the medium-fed group at $P<0.05$.
** Significantly different from the medium-fed group at $P<0.01$.
[a] Individual regression coefficients were determined and, for the two boars on the same treatment, were pooled only if a "t" test did not show them to be heterogeneous.

ulate, and spermatozoa concentration for the limited-fed group were significantly different ($P<0.01$) from the medium-fed group. The regression coefficients of the volume measurements for one full-fed boar were significantly different ($P<0.01$) from the medium-fed group, while regression coefficients of the other full-fed boar were not. The number of spermatozoa per ml. of semen was inversely related to volume. This indicates that the output of the accessory glands was affected by feeding level, but the contribution of spermatozoa by the testes was not affected.

The rates of change in concentrations of fructose, of citric acid, and in total amount per ejaculate of citric acid, inositol, and non-protein nitrogen for the limited-fed boars were highly significantly different ($P<0.01$) from the medium-fed boars. Regression coefficients for inositol concentration, total fructose per ejaculate and protein nitrogen per ejaculate of the limited-fed group were significantly ($P<0.05$) more negative than those of the medium-fed group. The regression coefficients were not significantly different among groups with respect to concentrations of protein nitrogen and non-protein nitrogen, nor were those of the full-fed group significantly different from the medium-fed group in any of these five chemical constituents.

The regression coefficients for ergothioneine concentration (—.056) and total ergothioneine per ejaculate (—.203) for the full-fed boars were more negative than those of the medium-fed group. This was undoubtedly related to a decrease in feed intake of the full-fed boars as the experiment progressed as is discussed below. The average concentration of ergothioneine in boar semen was 34.7 mg. per 100 ml. and is very similar to the 31.2 mg. percent reported by Mann *et al.* (1956).

There is some evidence that ergothioneine in blood and semen is related to feed intake (Melville, 1959; Self, 1959). To determine the degree of association between monthly ergothioneine secretion and monthly feed consumption, correlation coefficients for the six boars were determined. The correlation coefficient for average monthly ergothioneine concentration per ejaculate with monthly feed consumption for all boars was 0.64($P<0.01$). For total ergothioneine per ejaculate with monthly feed consumption, the correlation coefficient was 0.69($P<0.01$).

The level of feed intake may have contributed to the level of protein nitrogen in the seminal fluid; however, because medium- and full-fed boars also showed decreases in seminal protein concentration, the regression coefficients among the three groups were not significantly different. Levels of feed intake had no effect upon the concentration of non-protein nitrogen secreted in the seminal plasma; however, all boars showed a decrease in the concentration of non-protein nitrogen during the summer months.

The fertility data are shown at the bottom of tables 2 and 3. Although the medium-fed group had a lower percentage of corpora lutea represented by normal embryos, there was no significant difference among the three groups in this characteristic or in percent conception. The 47.9% average conception and the 68.6% of corpora lutea in the pregnant gilts that were represented by normal embryos are in good agreement with values of 50.0% and 66.8%, respectively, reported by Stratman and Self (1960).

During the second phase of the experiment, only two ejaculates were obtained from limited-fed boar 190, both of which contained less than 2.5×10^9 spermatozoa per ejaculate. The other limited-fed boar recovered rapidly, as is indicated by the following regression coefficients which were obtained on data collected during the second phase: total volume of ejaculate, ml./day, 2.834; strained ejaculate volume, ml./day, 2.367; spermatozoa concentration, 10^6/ml./day, —4.736; fructose, citric acid, inositol and ergothioneine concentration, mg./100 ml./day, 0.302, 1.231, 6.071, and 0.322, respectively; fructose, citric acid, inositol and ergothioneine per ejaculate, mg./day, 1.127, 5.023, 20.559 and 1.365, respectively. All of these regression coefficients were significantly different ($P<0.01$) from the regression coefficients of the medium-fed boars. No fertility data and no nitrogen analyses were obtained during the second phase of the experiment.

For the medium-fed boars the regression coefficients of the second phase were not significantly different from those of the first phase.

After reversal to limited feeding, the full-fed boars showed a slight decrease in all characteristics except spermatozoa concentration, but only the change in concentration and total amount of ergothioneine approached significance during the second phase of the experiment.

Discussion

The results of this experiment are in good agreement with similar data reported by other authors. Mann and Walton (1953) found that concentrations of fructose and of citric acid in bull semen were reduced by 30% and 60%, respectively, as a result of underfeeding. Niwa (1954) reported that boars making subnormal growth reached ejaculatory capacity at an older age than did faster growing boars, but no effect of restricted feed intake existed after the boars had reached 7 months of age. Dutt and Barnhart (1959) found that the volume of semen from young boars raised on a restricted level of feed was less than from boars on a high plane of nutrition; total spermatozoa number, motility, cell concentration, percent morphologically abnormal spermatozoa and fertility were not affected.

The extreme degrees of underfeeding and of overfeeding imposed under the conditions of this experiment far exceed those normally encountered under ordinary management. Since backfat thickness did not increase in the medium-fed boars, their change in weight apparently was not due to accumulations of fat, but rather to growth and development. In this experiment medium feeding, but not limited feeding, was sufficient to maintain the volume of the ejaculate at starting levels. The effect of more frequent collection than twice per week has not been studied. The ability of a mature boar to withstand extreme underfeeding for prolonged periods without spermatogenesis being affected is clearly shown in this experiment by the fact that the total number of spermatozoa per ejaculate was not affected until the 14th month of the experiment.

As shown in table 4, regression coefficients for nearly all the chemical constituents studied with the number of days on test were negative. This effect may have been due to increase in age of the boars.

The amount of ergothioneine in boar semen was significantly ($P<0.01$) correlated with feed consumption. The decrease in ergothioneine concentration in semen of the full-fed boars as the experiment progressed was attributed to diminishing feed consumption of those boars. The average monthly feed consumption of the full-fed boars at the beginning of the experiment was about double that at the end of the first phase. Eagles and Vars (1928) demonstrated that feeding purified diets caused a decrease in the blood ergothioneine level of pigs and that it could be increased by feeding corn. Self (1959) reported that ergothioneine levels in semen of boars can be reduced by feeding a cereal-free diet. This observation plus the data of this experiment indicate a direct relationship between dietary ergothioneine and blood and semen ergothioneine levels. It is interesting to note that the ergothioneine in blood is intracellular while in semen it is extracellular. Mann and Leone (1953) found that ergothioneine protected boar spermatozoa against the paralyzing action of sulfhydryl inhibitors and suggested that it may function to prevent loss of motility resulting from the oxidation or complexing of —SH groups. Although wide variations in the concentration of ergothioneine were produced in this experiment, no effect on motility could be demonstrated in fresh semen.

The overall average of 286 mg. of inositol per 100 ml. of semen in this experiment is less than the 600 to 700 mg. per 100 ml. of seminal plasma reported as normal by Hartree (1957) and the 420 mg. per 100 ml. average of four ejaculates reported by Mann (1954). Inositol occurs in high concentrations in boar semen (Mann, 1951); however, its role needs to be more clearly elucidated. Mann (1954) postulates that inositol serves to maintain the osmotic pressure of the seminal vesicle secretion. Because of its structural similarity to fructose, and since the two compounds seem to occur together, it has been suggested that inositol may function in the accessory glands as an intermediate in the conversion of glucose and fructose (Hartree, 1957).

The 'citric acid test', in which the formation of citric acid by accessory glands is a reflection of androgenic activity, has been used by Mann (1954) to demonstrate that malnutrition manifests itself in a state of pseudo-hypophysectomy. As a result of lowered hypophyseal activity, the testes receive insufficient gonadotrophic stimulus and are unable to produce sufficient male sex hormone for normal functioning of accessory glands.

Of the seminal plasma constituents studied, the concentration of non-protein nitrogen, which represents primarily free amino acids, was most constant and was least affected by plane of nutrition. This is consistent with the idea that the testes are a major source of seminal free amino acids, primarily glutamic acid, and that the free amino acids are in some way associated with the production of

spermatozoa or in their maturation in the epididymis (Hopwood and Gassner, 1957).

The fact that the full-fed boars remained fertile even after accumulating extremely large amounts of fat substantiates other evidence that high planes of nutrition do not result in sterility (Reid, 1949). The breeding capacity of a fat boar when used for natural service is probably limited more by physical capability than by physiological capacity.

Since neither motility nor fertility could be related to the wide variations in concentrations of the various chemical constituents of seminal plasma which were encountered in this experiment, the role of these seminal plasma components appears to be of minor importance to artificial insemination when the semen is used within a few hours after collection. It seems unlikely, however, that the seminal plasma constituents are of no importance and perhaps the tests imposed in this experiment were not critical enough to demonstrate differences.

The rapid recovery of boar 182 during the second phase of this experiment demonstrated that the low plane of nutrition was primarily responsible for the decreased amounts of the various chemical constituents of the ejaculate. The slow recovery of boar 190 indicates that permanent damage may have been encountered.

Summary

Six Yorkshire boars, 22 months of age and of known fertility, were fed for 15½ months on one of three levels of nutrition, and semen was collected from each boar twice weekly. Semen volume was sharply reduced when feed intake was severely restricted; however, full-feeding did not increase semen volume over that obtained on a medium plane of nutrition. The concentration of spermatozoa increased as volume decreased so that the total number of spermatozoa per ejaculate was little affected by plane of nutrition until a point of lethargy due to restricted feed intake was approached. Spermatozoa concentrations as well as total spermatozoa per ejaculate were highest during the summer months. An increase in volume of the ejaculate was found during the early fall months. The total amounts per ejaculate and the concentrations in the semen of citric acid, fructose, ergothioneine and inositol varied greatly within and between boars with season and with age of the boars. However, the rates of decrease in these semen constituents as the experiment progressed were significantly faster in the limited-fed group than in the medium-fed group. Of the semen components studied, the amount of ergothioneine appeared to be most closely related directly to feed intake. The concentration of non-protein nitrogen showed less variation than other semen constituents and was not affected by plane of nutrition. While the regression coefficients were not significantly different, there was a trend for the protein nitrogen to be higher in full-fed boars, especially when their feed consumption was high. The chemical composition of seminal plasma with regard to the six components studied did not appear to be of importance to artificial insemination when the semen was used without an artificial diluent for inseminating immediately after collection.

Neither motility nor fertility of the freshly ejaculated spermatozoa was affected over a prolonged period, indicating that widely varying planes of nutrition can be tolerated by boars without detrimental effects on spermatozoa.

Literature Cited

Atkin, L., A. S. Schultz, W. L. Williams and C. N. Frey. 1943. Yeast microbiological methods for determination of vitamins. Ind. and Eng. Chem. Anal. Ed. 15:141.

Beeson, W. M., E. W. Crampton, T. J. Cunha, N. R. Ellis and R. W. Luecke. 1959. Nutrient Requirements of Swine. National Research Council Publication 648.

Dutt, R. H. and C. E. Barnhart. 1959. Effect of plane of nutrition upon reproductive performance of boars. J. Animal Sci. 18:3.

Eagles, B. A. and H. M. Vars. 1928. The physiology of ergothioneine. J. Biol. Chem. 80:615.

Folin, O. and H. Wu. 1919. A system of blood analysis. J. Biol. Chem. 38:81.

Halliday, J. W. 1955. Ph.D. Thesis. University of Wisconsin, Madison, Wisconsin.

Halliday, J. W. and L. Anderson. 1955. The synthesis of myo-inositol in the rat. J. Biol. Chem. 217:797.

Hartree, E. F. 1957. Inositol in seminal plasma. Biochem. J. 66:131.

Hopwood, M. L. and F. X. Gassner. 1957. Free amino acid concentration in bovine testes and accessory sex organs. J. Dairy Sci. 44:229. (Abstr.).

Johnson, M. 1941. Isolation and properties of a pure yeast polypeptidase. J. Biol. Chem. 137:575.

Mann, T. 1951. Inositol, a major constituent of the seminal vesicle secretion of the boar. Nature 168:1043.

Mann, T. 1954. The Biochemistry of Semen. J. Wiley and Sons, Inc., New York, N. Y.

Mann, T. and E. Leone. 1953. Studies on the metabolism of semen. 8. Ergothioneine as a normal constituent of boar seminal plasma. Purification and crystalization. Site of formation and function. Biochem. J. 53:140.

Mann, T., C. Polge and L. E. A. Rowson. 1956. Participation of seminal plasma during the pas-

sage of spermatozoa in the female tract of the pig and horse. J. Endocr. 13:133.
Mann, T. and A. Walton. 1953. The effect of underfeeding on the genital functions of a bull. J. Agr. Sci. 43:343.
Melville, D. B. 1959. Ergothioneine. Vitamins and Hormones. XVII:155.
Melville, D. B. and Rose Lubschez. 1953. A method for the determination of ergothioneine in blood. J. Biol. Chem. 200:275.
Niwa, T. 1954. Studies on the spermatogenic function of swine. I. Relationship between the body growth and spermatogenic function. Bul. Nat. Inst. Agr. Sci. Series G 8:17.
Niwa, T. and A. Mizuho. 1954. Studies on the spermatogenic function in swine. II. On the seasonal variation in spermatogenic function. Bul. Nat. Inst. Agr. Sci. Series G 8:31.
Reid, J. T. 1949. Relationship of nutrition to fertility in animals. J. Am. Vet. Med. Assn. 114:158.
Roe, J. H. 1934. A colorimetric method for the determination of fructose in blood and urine. J. Biol. Chem. 107:15.
Saffran, M. and O. F. Denstedt. 1948. A rapid method for the determination of citric acid. J. Biol. Chem. 175:849.
Self, H. L. 1959. The problem of storing and inseminating boar semen. Annales De Institut National De La Recherche Agronomique, Jouyen-Josas, France. Series D Ann. Zootech., Supplement pp. 121–134.
Steel, R. G. D. and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., Inc., New York, N. Y.
Stratman, F. W. and H. L. Self. 1960. Effect of semen volume and number of sperm on fertility and embryo survival in artificially inseminated gilts. J. Animal Sci. 19:1081.
Stratman, F. W., H. L. Self and V. R. Smith. 1958. Fertilization rates obtained with boar semen stored for zero and twelve hours. J. Animal Sci. 17:598.

COMPARATIVE DAILY CONSUMPTION AND DIGESTIBILITY OF SUMMER RANGE FORAGE BY WET AND DRY EWES

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IT is common knowledge that animals in lactation require more nutrients than those gestating or than dry animals simply maintaining their weight (Morrison, 1954; Crampton, 1956; Maynard, 1951).

To the knowledge of the authors, no data are available on the consumption of pasture or range forage for lactating compared to nonlactating animals.

For this reason, a study was conducted on mountainous range in northern Utah, during the summer grazing period of 1959, to determine the comparative daily consumption and digestibility of forage by wet and dry ewes.

Methods and Procedures

Temporary grazing paddocks were established on typical mountain-brush grass range. Paddocks varied from 5 to 11 acres, depending upon the quantity of forage. Eight dry ewes, eight wet ewes with 2-month-old lambs, and four additional dry ewes equipped with esophageal-cannulae fistulae were grazed in each paddock. All animals were considered in good flesh at the beginning of the study. Six of the dry ewes and six of the wet ewes were equipped with specially improvised bags for collecting feces. The bags were constructed with a narrow strip of fine screen on the lower side, starting near the bottom and extending up and between the back legs. This allowed the urine to drain off before saturating the feces. Much of the urine was emitted directly on the portion of the bag constructed of screen. Grab samples from unbagged sheep were used to check and correct for contamination of the feces by urine. Fecal samples from bagged animals were corrected for nitrogen and ash as a result of urine contamination, which was only slight in any case.

The average weight per ewe was approximately 120 lb. At the beginning of the trials the dry ewes weighed an average of 5 lb. more than the wet ewes.

Each trial period was preceded by a 6-day preliminary grazing period followed by a 5-day collecting period. In all trials, the forage was utilized only to a moderate degree at the end of the collection period. The fecal bags were emptied once in the early morning and once in the evening. Forage samples were collected from each fistulated sheep during the morning grazing period. Composite samples of forage and feces were taken for each animal for each trial for chemical analysis.

Forage sample collections were started 24 hours before the first fecal collections were taken and they were terminated 24 hours before the final fecal collection at the end of the 5-day collection period.

Herbage production and diets were determined by the method outlined by Edlefsen *et al.* (1960). Dry matter intake and digestibility coefficients were determined by the lignin-ratio technique (Cook *et al.*, 1951). All data are presented on an oven-dry basis.

Results and Discussion

Diets. The diets during the four summer periods are shown in table 1. The species composition of the diet changed markedly from one grazing area to another. However, on most areas Kentucky bluegrass, longleaf aster, and bitterbrush made up the major portion of the diet. These three species were relatively abundant on most of the study areas and were readily eaten in all cases.

During the first grazing period—July 10 to July 15—grasses were more abundant in the diet than either forbs or browse. However, during the last three periods, browse made up a larger percent of the diet than either the forbs or grasses. Forbs produced more forage per acre than grasses and somewhat less than browse, but they were always intermediate in percent of the diet (table 1).

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TABLE 1. AVERAGE PRODUCTION, UTILIZATION AND DIETS FOR FOUR MOUNTAIN SUMMER RANGE AREAS GRAZED BY BOTH WET AND DRY EWES

Species				Diets for areas				
Common name	Scientific name	Average production	Average utilization	1 July 10–15	2 Aug. 6–11	3 Aug. 26–31	4 Sept. 16–21	Average diet July 10–Sept. 21
		(lb./acre)	%	%	%	%	%	%
Kentucky bluegrass	(*Poa pratensis*)	129.63	50.18	38.69	14.16	30.08	30.27	35.00
Sandberg bluegrass	(*Poa secunda*)	5.83	2.72	0.14	0.05	0.00	0.01	0.09
Mutton grass	(*Poa fendleriana*)	17.78	16.46	6.15	0.60	1.26	0.34	1.56
Columbia needlegrass	(*Stipa columbiana*)	18.53	3.44	0.63	0.31	0.00	0.10	0.34
Letterman needlegrass	(*Stipa lettermani*)	10.54	5.77	1.25	0.20	0.00	0.02	0.32
Squirreltail grass	(*Sitanion hystrix*)	15.52	0.10	0.00	0.10	0.00	0.02	0.01
Mountain brome	(*Bromus carinatus*)	4.81	1.19	0.14	0.01	0.03	0.04	0.03
Slender wheatgrass	(*Agropyron trachycaulum*)	9.33	3.91	3.40	0.61	0.04	0.01	0.19
Bearded wheatgrass	(*Agropyron subsecundum*)	8.49	6.58	0.82	0.19	....	0.00	0.30
Western wheatgrass	(*Agropyron smithii*)	28.75	3.87	....	....	0.81	0.90	0.60
Sedges	(*Carex spp.*)	7.17	3.08	1.21	0.03	0.00	0.03	0.12
Oniongrass	(*Melica bulbosa*)	2.79	0.00	0.00	0.00	0.00	0.00	0.00
Downy brome	(*Bromus tectorum*)	1.34	0.00	0.00	....	....	....	0.00
Giant wildrye	(*Elymus cinereus*)	62.55	0.24	0.08	0.19	....	0.00	0.30
June grass	(*Koeleria cristata*)	9.22	67.76	....	1.54	3.30	1.03	3.36
Grass		332.28	23.52	52.51	18.17	35.60	33.01	42.00
Longleaf aster	(*Aster adscendens*)	140.40	30.68	....	27.26	14.31	11.77	23.15
Bastard toadflax	(*Commandra umbellata*)	43.32	5.00	....	0.62	0.57	1.78	1.17
Agroseris	(*Agroseris glauca*)	0.22	0.00	....	0.00	0.00	....	0.00
Yarrow	(*Achillea lanulosa*)	17.80	0.00	0.00	0.00	0.00	0.00	0.00
Lupine	(*Lupinus laxiflorus*)	74.57	14.21	4.41	0.50	0.11	1.89	5.70
Geranium	(*Geranium fremontii*)	90.91	5.35	1.63	4.93	0.29	0.82	2.63
Eriogonum	(*Eriogonum heracloides*)	19.74	5.39	....	0.58	0.02	0.07	0.57
Goat beard	(*Tragopogon porrifolius*)	2.93	31.77	2.38	0.10	0.19	0.31	0.50
Mule ears	(*Wyethia amplexicaulis*)	5.37	0.00	....	0.00	....	....	0.00
Everlasting	(*Antennaria spp.*)	3.65	0.00	....	0.00	0.00	....	0.00
Hawkweed	(*Hieracium scouleri*)	6.15	6.67	0.12	0.24	0.11	1.15	0.22
Knotweed	(*Polygonum douglasii*)	22.49	14.44	....	0.61	2.16	....	1.75
Fireweed	(*Epilobium angustifolium*)	15.30	2.18	2.01	0.04	0.00	0.00	0.18
Ivory seeded borage	(*Lithospermum ruderale*)	9.60	13.11	....	1.22	0.31	0.00	0.68
Cinquefoil	(*Potentilla spp.*)	0.52	1.10	0.00	....	0.01	....	0.01
Thistle	(*Cirsium spp.*)	3.23	0.00	0.39	....	....	....	0.00
Prickly lettuce	(*Lactuca serriola*)	1.17	1.65	0.21	....	0.00	....	0.01
Hound's tongue	(*Cynoglossum officinale*)	0.48	0.00	0.00	....	....	....	0.00
Dandelion	(*Taraxacum officinale*)	2.89	....	0.54	....	....	....	....
Biscuitroot	(*Lomatium grayi*)	0.53	0.00	....	....	0.00	....	0.00
Wild strawberry	(*Fragaria spp.*)	0.39	8.30	0.17	....	....	....	0.02
Butterweed	(*Senecio serra*)	0.18	0.00	0.00	....	0.00	....	0.00
Vetch	(*Viccia americana*)	10.92	0.00	....	....	....	....	0.00
Goldenrod	(*Solidago spp.*)	13.22	0.50	....	....	0.01	1.04	0.04
Forbs		485.98	14.09	12.03	36.10	18.09	19.23	36.63
Big sagebrush	(*Artemisia tridentata*)	359.45	0.39	0.00	2.25	0.00	0.00	0.75
Rabbitbrush	(*Chrysothamnus viscidiflorus*)	186.90	0.00	0.00	....	....	....	0.00
Bitterbrush	(*Purshia tridentata*)	158.52	18.32	34.32	32.83	43.54	47.18	15.63
Snowberry	(*Symphoricarpos vaccinioides*)	54.29	1.01	0.00	0.30	0.09	0.12	0.30
Wild rose	(*Rosa woodsii*)	6.21	14.31	0.82	0.84	0.07	0.27	0.48
Aspen	(*Populus tremuloides*)	4.84	1.30	0.32	....	....	....	0.03
Chokecherry	(*Prunus virginiana*)	2.50	2.50	....	....	....	0.02	0.03
Service berry	(*Amelanchier alnifolia*)	21.35	36.22	....	9.51	2.61	0.17	4.16
Browse		794.06	4.96	35.46	45.73	46.31	47.77	21.38
Total		1612.32	11.53	100.00	100.00	100.00	100.00	100.00

Nutrient Content of the Diet. There were substantial differences in the nutrient content of the diets among the various areas (table 2). Total protein in the diet decreased from the first to the last grazing trial and ether extract increased. Lignin content of the diet during the last three periods was considerably higher than the first period. The cellulose content of the diet appeared to decrease as lignin increased.

These changes in nutrient content of the diet from area to area during the summer could be a result of increased plant maturity, differences in portions of the plants consumed from time to time, or relative abundance of the three forage classes in the diet.

Digestibility of Nutrients. The digestibility of protein was somewhat lower in the last two trials compared to the first two (table 3). The digestibility of cellulose, gross energy, and dry matter decreased with each succeeding period from area 1 to area 3, but increased slightly for the last area. The digestibility of other carbohydrates varied somewhat from area to area, but differences were not great in any case.

No significant differences in digestibility of nutrients were evident between wet and dry

TABLE 2. AVERAGE NUTRIENT CONTENT OF THE DIET OF EWES–EQUIPPED WITH ESOPHAGEAL FISTULAE ON MOUNTAINOUS SUMMER RANGE GRAZED BY WET AND DRY EWES[a]

Area and date	Ether extract	Total protein	Ash	Lignin	Cellulose	Other carbo-hydrates	Phosphorus	Gross energy
	%	%	%	%	%	%	%	(kcal/lb.)
1—July 10–15	3.0	14.2	9.7	12.4	22.8	37.9	0.40	2157
2—Aug. 6–11	3.4	11.6	11.4	16.2	17.9	39.5	0.40	2041
3—Aug. 26–31	4.6	11.5	11.4	16.7	17.5	38.3	0.39	2013
4—Sept. 16–21	5.0	10.6	9.9	15.4	19.4	39.7	0.24	2088
Average	4.0	12.0	10.6	15.2	19.4	38.8	0.35	2075

[a] Corrected for nitrogen, ash, and phosphorus contained in the saliva.

ewes. During some trials wet ewes appeared to digest some of the nutrients better than dry ewes, but in other trials the reverse was true.

Daily Intake. During all trials, wet ewes consumed significantly more forage than dry ewes ($P<.05$). Wet ewes consumed an average of 3.87 lb. of dry matter daily and dry ewes consumed only 3.07 lb. per day (table 3). Thus, wet ewes consumed about 26% more forage per day than dry ewes.

Requirements. Since mountainous summer range is used primarily for lactating animals, the results are compared to requirements for lactation.

The requirements established by the N.R.C. (1957) for a 120-pound ewe in the later stages of lactation were amply met for protein in the first part of the season, but were slightly deficient during the latter part (table 3). Only during the first period did the diet of the grazing animals approach the recommended energy requirements. This was true for both total digestible nutrients and digestible energy.

The wet ewes lost weight slightly during all grazing periods and the dry ewes and lambs gained weight during all periods. Wet ewes lost 0.06 lb. per day during the first part of the season from July 1 to August 25 and 0.09 lb. per day during the latter part from August 26 to September 22, compared to dry ewes which gained 0.18 lb. per day during the early grazing season and 0.02 lb. per day during the late summer grazing season. Lambs gained 0.35 and 0.31 lb. per day during early and late summer, respectively.

Most of the ewes, both wet and dry, carried fecal bags during four 5-day collection periods for a total of 20 days out of 82 grazing days during the summer. However, there was no discernible difference in response between animals carrying bags and animals not carrying bags. Numbers of animals were too small and collection periods too short to determine accurately the effect of carrying a fecal bag intermittently on weight changes.

Summary and Conclusions

During the summer of 1959, a study was made on mountainous range to determine the comparative daily consumption and digestibility of forage by wet and dry ewes.

Both wet and dry ewes equipped with fecal bags were grazed in temporary paddocks. Daily intake and digestibility was determined by the lignin-ratio technique.

On all study areas, forbs produced more forage than grasses and somewhat less than browse, but they were intermediate in percent of the diets. On some areas, grasses made up the majority of the diet. On others, browse made up more of the diet than grasses.

The nutrient content of the diet changed decidedly from area to area. This might be a result of increased plant maturity, differences in portions of the plants consumed, or relative abundance of each of the three forage classes in the diet.

In general, the digestibility of most nutrients decreased somewhat from the first to the last period during the summer.

There were no significant differences in digestibility of nutrients between wet and dry ewes.

Wet ewes consumed about 26% more forage per day than dry ewes.

Wet ewes lost from 0.06 to 0.09 lb. per day, whereas dry ewes and lambs gained from 0.02 to 0.18 and 0.31 to 0.35 lb. per day, respectively.

TABLE 3. AVERAGE DIGESTIBILITY OF NUTRIENTS IN FORAGE FROM MOUNTAINOUS SUMMER RANGE GRAZED BY WET AND DRY EWES

Area and date	Phase of animal production	Intake per day	Percent digested						Digestible protein	Digestible energy	Total digestible nutrients	Digestible protein	Digestible energy	Total digestible nutrients
			Ether extract	Total protein	Cellulose	Other carbohydrates	Gross energy	Dry matter						
		(lb.)							(%)	(kcal/lb.)	(%)	(lb.)	(therms)	(lb.)
1—July 10–15	Wets	3.04	—26.2	51.5	62.6	69.3	51.0	51.3	7.31	1107	47.8	0.222	3.365	1.45
	Drys	2.02	—41.8	47.5	64.9	65.2	49.6	49.5	6.74	1070	46.3	0.136	2.161	0.94
	Average	2.53	—34.0	49.5	63.8	67.3	50.3	50.4	7.02	1088	47.0	0.178	2.753	1.19
2—Aug. 6–11	Wets	4.05	—37.2	53.4	52.5	71.3	45.5	50.1	6.19	929	43.8	0.250	3.762	1.77
	Drys	2.91	—51.1	47.8	50.8	70.9	43.3	46.4	5.54	884	42.6	0.161	2.572	1.24
	Average	3.48	—44.2	50.6	51.7	71.1	44.4	48.2	5.86	906	43.2	0.204	3.152	1.50
3—Aug. 26–31	Wets	3.99	—49.4	35.9	36.9	68.4	35.9	37.2	4.13	723	36.8	0.165	2.885	1.47
	Drys	3.58	—53.7	39.0	38.0	69.4	36.8	38.9	4.48	741	37.7	0.160	2.653	1.35
	Average	3.78	—51.5	37.4	37.5	68.9	36.4	38.0	4.30	732	37.2	0.162	2.767	1.41
4—Sept. 16–21	Wets	4.39	—22.4	32.8	47.4	62.6	37.4	40.4	3.48	781	37.8	0.153	3.429	1.66
	Drys	3.76	—12.8	42.3	53.6	64.4	45.9	48.1	4.48	958	40.0	0.168	3.602	1.50
	Average	4.07	—17.6	37.6	50.5	63.5	41.6	44.2	3.98	869	38.9	0.162	3.537	1.58
Average	Wets	3.87	—33.8	43.4	49.9	68.9	42.5	44.8	5.27	885	41.6	0.204	3.425	1.61
	Drys	3.07	—39.8	44.2	51.8	67.5	43.9	45.7	5.31	913	41.7	0.163	2.803	1.28
	Average	3.47	—36.8	43.8	50.8	68.2	43.2	45.2	5.29	899	41.7	0.184	3.119	1.45
Requirements[a]		4.20	....	....	....	....	....	....	4.30	1047	52.0	0.180	4.400	2.20

[a] Requirements for last 12–14 weeks of lactation as presented by the National Research Council (N.R.C., 1957).

Literature Cited

Cook, C. Wayne, L. A. Stoddart and Lorin E. Harris. 1951. Measuring consumption and digestibilty of winter range plants by sheep. J. Range Management 4:355.

Crampton, E. W. 1956. Applied Animal Nutrition. W. H. Freeman & Co., San Francisco, California.

Edlefsen, James L., C. Wayne Cook and Joseph T. Blake. 1960. Nutrient content of the diet as determined by hand plucked and esophageal fistula samples. J. Animal Sci. 19:560.

Maynard, L. A. 1951. Animal Nutrition. (3rd ed.) McGraw-Hill Book Co., Inc., New York, N. Y.

Morrison, Frank B. 1954. Feeds and Feeding. (21st ed.) The Morrison Publishing Co., Ithaca, New York.

N.R.C. 1957. Nutrient Requirements of Domestic Animals. Number V. Nutrient Requirements of Sheep. Revised 1957. National Research Council, Washington, D. C.

EFFECT OF PRE-SLAUGHTER DIETARY STRESS ON THE CARCASS CHARACTERISTICS AND PALATABILITY OF PORK [1]

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RESTRICTED food intake by meat animals during the fattening period results in less fat deposition and accordingly a higher proportion of lean meat. This effect has been demonstrated in hogs by various methods of limiting the caloric intake. Pomeroy (1941) demonstrated that limited feeding in the latter half of the growing and fattening period resulted in a greater percent of lean meat in the carcass than did full feeding until slaughter weight. When the animals were severely restricted, the thickness of backfat was markedly reduced.

Winters *et al.* (1949) and Brugman (1950) found some general improvement in carcass leanness when feed was restricted either in the early or late period of fattening. Crampton *et al.* (1954) found that restricted feeding during the last part of the fattening period increased the proportion of lean but suggested that dilution of the ration with crude fiber was a more practical approach to producing carcasses with a higher proportion of lean meat. Crampton and associates (1954) and Merkel *et al.* (1958) demonstrated that the lean-fat ratio could be increased in this manner.

In this study differences in carcass composition were induced by maintenance and submaintenance rations after the hogs had reached the weight at which they would normally be slaughtered.

Experimental

This experiment was part of a broader study of factors influencing pork quality. Forty-eight Duroc hogs were fed a growing-fattening ration (Ration 1) up to approximately 230 lb. Trios of similar hogs were chosen on the basis of weight, sex, littermates if possible, and backfat thickness as determined by the probe technique. One hog from each trio was then randomly allotted to one of three treatment lots, each consisting of 16 animals. Lot I served as the control; Lot II was placed on a maintenance ration; and Lot III was placed on severe dietary restriction. The weight at which the animal began the treatment was between 225 and 235 lb. or the weight of the heaviest animal of the trio, whichever was the greater. The control animal was slaughtered when this weight was reached and at a comparable weight, each animal from the other two lots was placed on the appropriate treatment. An animal in Lot II remained on a maintenance ration for the same period of time the third member of the trio (Lot III) took to lose approximately 12% of its body weight. If the animal allotted to Lot II was the heaviest of the trio, the animal was held on the maintenance ration for a period of 4 weeks prior to slaughter. The 4-week period was selected as the approximate time required for the animals in Lot III to lose 12% of their body weight.

The live animal backfat probes were taken approximately 1½ in. to the right of the midline of the back and in positions immediately above the animal's fore flank (about the 7th or 8th rib), at the linear center of the loin area (about the 13th rib) and immediately above the rear flank (about the 5th lumbar vertebra). Measurements were made with a metal rule graduated to the nearest 1/10 in.

The feed mixtures used in this study are indicated in table 1. All hogs were fed the standard ration (Ration 1) to slaughter weight. Thereafter, each animal in Lot II received not more than 3 lb. of feed per day

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TABLE 1. COMPOSITION OF RATIONS

Ingredient	Percent composition		
	Ration[a] 1	Ration[b] 2	Ration[c] 3
Ground yellow corn	90.125	79.25	44.50
50% Soybean oil meal	8.000	18.00	50.00
Dicalcium phosphate	0.700	1.00	2.00
Ground limestone	0.700	1.00	2.00
Trace mineralized salt	0.350	0.50	1.00
Vitamin A supplement[d]	0.050	0.10	0.20
Illini vitamin mix[e]	0.050	0.10	0.20
Antibiotic supplement[f]	0.025	0.05	0.10

[a] Ration 1 constituted the ration used for the full-fed period for all animals.
[b] Ration 2 represents the diet used in the maintenance group.
[c] Ration 3 was used for the "severely restricted diet" group.
[d] 5,000 units of vitamin A and 625 units of vitamin D/gm.
[e] Riboflavin .5 gm./lb.
Calcium pantothenate 2.5 gm./lb.
Niacin 7.5 gm./lb.
Choline chloride 50.0 gm./lb.
Vitamin B_{12} 8.0 mgm./lb.
[f] Procaine penicillin 5 gm./lb.
Streptomycin 15 gm./lb.

(Ration 2), with the amount adjusted weekly to account for weight gains or losses during the preceding week. Those in Lot III were fed 1 lb. of a special feed mix (Ration 3) per day. All animals in Lot II and III were fed individually. While on the experimental treatment, the hogs had access to water at all times.

The animals were slaughtered at the University of Illinois Meat Laboratory. After dressing and chilling, carcass length and backfat were measured. Additional carcass information was obtained at the time of cutting (loin-eye area, percent lean cuts and pounds of lean) and is indicated in the results. Free moisture values were determined at both laboratories. At the University of Illinois the mean of three meat samples taken from the medial, central and lateral portions of the *longissimus dorsi* of a rib chop which included the 10th rib of the left loin is reported. Samples of approximately 500 mg. were weighed to the nearest 0.1 mg., transferred to the center of Whatman No. 2, 11 cm. filter paper, and covered with a piece of trace-o-film (acetate). The prepared sample was placed between two plexi-glass plates and held under 1000 psi. for 5 minutes. The outer edge of the moisture area and meat area were traced on the trace-o-film for a permanent record. Areas were obtained by using a compensating polar planimeter. At the American Meat Institute Foundation laboratory, the procedure of Wierbicki and Deatherage (1958) was followed using meat from a comparable location in the right loin.

After cutting, the right loins were shipped by rail to the American Meat Institute Foundation in Chicago. The loins were enroute about 3 hours and arrived with an internal temperature of approximately 40° F.

The portion of the loin between the 11th rib and the posterior side at the 3rd lumbar vertebra was used as a roast. Starting at the 3rd lumbar vertebra six ¾ in. chops were cut from the remaining loin.

Marbling of the rib-eye between the 2nd and 3rd lumbar vertebra was scored on a nine point scale—slight, abundant and very abundant each with a plus, average, and minus level.

The *longissimus dorsi* in the 7–10th rib section was ground and used for the determination of pH, myoglobin, moisture, fat and protein. A 10 gm. sample of ground meat was homogenized with 90 ml. of water in a Waring Blender and the pH of the homogenate determined. The aliquot for myoglobin determination was placed into a Cryovac bag and frozen at —20° F. until analyzed. When the determinations were made, 10 gm. of the thawed sample were homogenized with 15 ml. of deionized water in an Omni-mixer for 30 sec. This homogenate was then filtered twice through Reeve Angel (#812) fluted filter paper. The optical density (O.D.) of the filtrate was read at 525 mu. in a Bausch & Lomb Spectronic 20. The myoglobin content in mg. per gm. of fresh tissue was calculated using the formula $\frac{\text{O.D. x 2.4,}}{.452 \times 10}$ where 0.452 is the extinction coefficient at 525 mu. in the instrument, 2.4 is the dilution factor and 10 gm. is the amount of pork used for the determination.

The roasts were cooked at 350° F. to an internal temperature of 185° F. for taste panel evaluation. Chops from the posterior portion of the loins were cooked by standard braising and broiling procedures, to an internal temperature of 185° F., using the odd numbered chops for braising and the alternate ones for broiling. Two chops from each cooking method were used for taste panel evaluation and the remaining one for the determination of Warner-Bratzler shear values. The percent yield was determined for both chops and roasts. The meat samples were given a score between one and nine for tenderness, juiciness, odor and flavor, where a high score represented greater acceptability. After cooking, the chops to be used for shear values were cooled to an average temperature of

50° F. in a refrigerator. Shear values were obtained 4 to 24 hours after cooking on five ½ in. cores removed from each chop.

Results and Discussion

The data were subjected to analyses of variance. In those instances where the F values indicated significance greater than the 5% probability level, the differences between lot means were tested for significance by applying the method of Duncan described by Steel and Torrie, (1960).

The most notable effect of the pre-slaughter treatments was a decrease in the amount of fat in both the maintenance and restricted fed lots. Measures of carcass composition of the three lots are shown in table 2.

The average of the three backfat probes made at the time the animals were started on their respective pre-slaughter treatments indicates that the maintenance and sub-maintenance groups had the same depth of fat in these areas; the control lot had only slightly more (0.1 in.) than these groups. For this reason it would appear that any differences in backfat thickness of Lots II and III at the time of slaughter resulted largely from restricted feed intake. The average backfat depth of the lot on a maintenance ration was reduced by 0.1 in., and the restricted group by 0.3 in. below that of the control group. Also, as measured by the weight of the four lean cuts and the rib-eye area, the group on the maintenance ration made an apparent increase in muscle weight during this period while the severely restricted group only maintained muscle weight. The group on the maintenance ration had an average live weight increase of 5 lb. during the treatment period, which is inconsistent with an increase of 8.4 lb. of lean cuts. This inconsistency probably arises from variations in fill, and possibly in cutting and trimming procedure, but the results are highly indicative of an increase in musculature and a continuation of "growth" during the maintenance period.

TABLE 2. EFFECT OF MAINTENANCE AND SUB-MAINTENANCE DIETS ON CARCASS CHARACTERISTICS

	Mean		
Characteristic	Lot I (Control)	Lot II (Maintenance)	Lot III (Sub-maintenance)
Loin eye area (sq. in.)	3.7	4.0	4.0
Carcass length (in.)	30.3	31.0	30.3
Av. carcass backfat (in.)	1.8	1.7	1.5**
Av. backfat—probe prior to exp. treat. (in.)	1.7	1.6	1.6
Marbling score	6.5	5.3	4.9
Fat %	10.8	9.0	7.9*
H_2O %	67.8	68.9	70.1*
Protein %	20.7	21.6	21.6
pH (*L. dorsi*)	5.61	5.55	5.64
Myoglobin (mg./gm.)	0.81	0.76	0.91
Dressing %	72.2	73.3	73.6*
Lean cuts %	46.3	48.8*	49.0**
Trimmed lean cuts (lb.)	80.9	89.3**	81.2
Age (days)	213	248	245
Slaughter weight (lb.)	242	249	225
Weight prior to exp. treatment (lb.)	...	244	250

* $P<.05$, compared with Lot I.
** $P<.01$, compared with Lot I.

The sub-maintenance feeding treatment which reduced the amount of subcutaneous fat also significantly reduced the level of fat in the *longissimus dorsi* as shown by the analysis in table 2. The difference between the control and maintenance lots was not significant but the mean values indicate some reduction of intramuscular fat in the latter group. Marbling scores followed the same pattern as the analysis of intramuscular fat but the differences were not statistically significant.

The effects of a sub-maintenance diet observed in the experiment are in general agreement with those of Pomeroy (1941). In his study, the animal which was on a sub-maintenance diet for 23 days lost 0.29 in. of backfat, which is about equal to that lost by the animals on a somewhat comparable feeding regime in the present experiment. Losses of intramuscular fat in the present experiment were 16% and 27% for the maintenance and restricted lots respectively. These losses were considerably greater than those found by Pomeroy.

The reduction in intramuscular fat in the maintenance and restricted group was accompanied by significantly reduced tenderness of the cooked product. A reduced tenderness score for braised and broiled chops and roasts was noted. Mean values for palatability factors and other characteristics of the loin are shown in table 3. The reduced tenderness of the cooked meat from the restricted feeding group was also reflected in the significantly higher Warner-Bratzler shear values in both broiled and braised chops. The relationship between intramuscular fat in fresh pork and tenderness has been shown by Kauffman (1959), Pohl (1959), Harring-

TABLE 3. EFFECT OF MAINTENANCE AND SUB-MAINTENANCE DIETS ON COOKING LOSSES AND PALATABILITY CHARACTERISTICS

Characteristic	Mean		
	Lot I	Lot II	Lot III
Roasts			
Tenderness	6.6	5.7**	5.2**
Juiciness	5.9	5.3**	5.1**
Odor	5.4	5.2	5.0**
Flavor	5.4	5.3	5.1*
Broiled chops			
Tenderness	5.9	5.3**	4.9**
Juiciness	5.5	5.3	5.0**
Odor	5.5	5.1**	4.9**
Flavor	5.4	5.0**	4.9**
Braised chops			
Tenderness	5.5	4.8**	4.5**
Juiciness	4.9	4.6*	4.4**
Odor	5.1	4.9	4.9
Flavor	5.1	4.9	4.6**
Shear, lb. (broiled chops)	6.0	6.8	7.7**
Shear, lb. (braised chops)	6.3	7.7**	8.1**
Yield% (broiled chops)	66.8	64.8	65.4
Yield % (braised chops)	74.3	74.6	74.9
Yield % (roasts)	74.8	71.8**	73.6
Drip % (roasts)	8.7	8.6	7.2
Evaporation % (roasts)	16.6	19.6*	19.2*
U. of I. free H_2O (ratio)	1.31	1.86**	1.81**
A.M.I.F. free H_2O (ratio)	2.44	2.50	2.64*
Roast weight (gm.)	1161	1208	1212

* $P<.05$, compared with Lot I.
** $P<.01$, compared with Lot I.

ton and Pearson (1960), Naumann *et al.* (1960) and Kauffman *et al.* (1961). Each of these studies provides evidence of the desirability of maintaining a certain amount of marbling in pork which is merchandised in the uncured form.

Juiciness scores were also directly related generally to the fat level in the rib-eye. With the exception of the broiled chops from hogs on the maintenance diet, the feeding treatments significantly reduced the juiciness of chops and roasts.

The most pronounced effect of treatment on the flavor and odor of the cooked meat was noted for broiled chops. A lesser effect was shown in braised chops, and in roasts only the effect of the sub-maintenance ration was significant. It is thought that these effects are directly associated with the differences in intramuscular fat content induced by the pre-slaughter treatment. Because surface browning contributes to flavor and odor, and requires fat for its development, the greatest difference in palatability between fat levels would exist when the pork was broiled. Differences due to intramuscular fat probably would not be as great when added fat was used in browning the chops in the braising process. Since no browning occurs directly on the lean meat area of a roast, differences due to browning would be minimized and the flavor differences observed in roasts may be due largely to inherent flavor differences rather than browning during cooking.

The yield of cooked meat was significantly less for those roasts from animals on the maintenance ration but a similar reduction was not noted for the group on restricted feeding. There seems to be no apparent explanation for this difference as the average drip loss and roast weight were similar for the three groups. Evaporative cooking losses were greater in roasts from animals on the restricted feed. There was no significant difference in yield of broiled or braised chops between the treatment groups.

The lots did not differ significantly in the amount of myoglobin in the fresh tissue (table 2). This indicates to some extent that myoglobin concentration is not influenced by dietary stress.

The pre-slaughter treatment of the animals had a significant effect on the free moisture content of the rib-eye as determined by the procedure adapted at the University of Illinois laboratory. The procedure of Wierbicki and Deatherage used at the American Meat Institute Foundation laboratory indicated poorer moisture holding properties only in those animals which were on the sub-maintenance treatment. As indicated previously, the determinations of free moisture were not performed after the same length of post-mortem storage and this may be a partial explanation for the difference between the results of the two procedures. To measure the usefulness of either of the procedures in predicting moisture retention during processing, correlation coefficients between free moisture values and evaporative cooking losses of roasts were determined. These are shown in table 4.

The free moisture values determined at the University of Illinois are expressed more accurately as a ratio because the moisture content of the free moisture area was not established for the procedure. The results show that the measure of free moisture by the filter paper press technique employed at the University of Illinois is a satisfactory one for predicting the evaporative losses in pork roasts and also may indicate the importance of the time from slaughter when the determinations

TABLE 4. CORRELATION COEFFICIENTS BETWEEN COOKING LOSSES AND FREE MOISTURE VALUES OF PORK

	Free moisture			
	Univ. of Illinois		Amer. Meat Institute Fdn.	
Losses	Ratio[a]	%	Ratio[a]	%
Evap., %	0.472**	0.453**	0.203	0.257
Yield, %	−.306*	−.188	−.255	−.203

* $P<.05$.
** $P<.01$.
[a] Ratio=Free moisture area to free moisture area plus meat film area.

are performed. The yield of cooked roasts undoubtedly is affected by the thickness of fat cover and should not be expected to be as predictable from free moisture values as evaporative losses.

Summary

In this experiment 48 pigs were divided into three groups for pre-slaughter treatment. One group was slaughtered as a control, the second group, after attaining slaughter weight, was put on a maintenance diet for approximately 4 weeks, and the third group was put on a restricted diet which reduced body weight 12% below the slaughter weight of the other groups.

The most apparent effect of the experimental treatments was the loss of backfat from both the maintenance and restricted groups. The results indicate that animals on the maintenance ration had an increased percentage of lean cuts because they continued to increase in muscle weight as well as lose fat during this period. Restricted feeding also increased the percentage of lean cuts, but the increase resulted entirely from a reduced backfat thickness.

The reduction in intramuscular fat in the loin followed a pattern similar to that of the subcutaneous fat; it was reduced by both experimental treatments but to a greater extent in the restricted group. Marbling scores showed a similar difference. The reduction of intramuscular fat was accompanied by reduced tenderness, juiciness, odor and flavor of the pork cooked as roasts or chops.

Cooking losses were also increased by the dietary restriction. Free moisture values determined 48 to 80 hours after slaughter were correlated with evaporative cooking losses.

The severe treatments imposed in this study are not encountered in commercial production but in some instances animals may be exposed to some degree of restriction immediately prior to slaughter. This study confirms the results of other workers as regards the depletion of fat but also shows that the dietary restriction of hogs at slaughter weight is deleterious to the eating quality of meat.

Literature Cited

Brugman, H. H. 1950. The effect of plane of nutrition on carcass quality of a line of swine based on Chester White and Danish Landrace cross. J. Animal Sci. 9:602.

Crampton, E. W., G. C. Ashton and L. E. Lloyd. 1954. Improvement of bacon carcass quality by the introduction of fibrous feeds into the hogs finishing ration. J. Animal Sci. 13:327.

Harrington, G. and A. M. Pearson. 1960. Chew count as a measure of tenderness in pork loins of varying degrees of marbling. J. Animal Sci. 19:1235.

Kauffman, R. G. 1959. Techniques of measuring some quality characteristics in pork. Proc. 12th Annual Reciprocal Meat Conf. p. 154, National Live Stock and Meat Board, Chicago, Illinois.

Kauffman, R. G., R. W. Bray and M. H. Schaars. 1961. Price vs. marbling in the purchase of pork chops. Food Technol. 15:22.

Merkel, R. A., R. W. Bray, R. H. Grummer, P. H. Phillips and G. Bohstedt. 1958. The influence of limited feeding, using high fiber rations, upon growth and carcass characteristics of swine. J. Animal Sci. 17:13.

Naumann, H. D., V. J. Rhodes and J. D. Volk. 1960. Sensory attributes of pork differing in marbling and firmness. J. Animal Sci. 19:1240, (Abstr.).

Pohl, Carol V. 1959. Palatability characteristics of loins from hogs of known history. Proceedings AMIF Industry Research Report Meeting. American Meat Insitute Foundation Circular No. 51, pp. 48.

Pomeroy, R. W. 1941. The effect of a submaintenance diet on the composition of the pig. J. Agr. Sci. 31:50.

Steel, Robert G. D. and J. H. Torrie. 1960. Principles and Procedures of Statistics. p. 107–109. McGraw-Hill Book Company, Inc., New York.

Wierbicki, E. and F. E. Deatherage. 1958. Determination of water-holding capacity of fresh meats. J. Agr. Food Chem. 6:387.

Winters, L. M., C. F. Sierk and J. N. Cummings. 1949. The effect of Plane of Nutrition on the Economy of Production and Carcass Quality of Swine. J. Animal Sci. 8:132.

INHERITANCE OF TEAT NUMBER AND RELATIONSHIP OF TEAT NUMBER TO VARIOUS MATERNAL TRAITS IN SWINE [1]

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SWINE breeders have attached considerable importance to teat number when selecting breeding stock. Attention to this trait has not been confined to females where teats are of functional importance but has also been considered in selection of male breeding stock. To justify selection for teat number in the male, it is important that the trait show at least a moderate amount of genetic variation in males so that it will be reflected in their female progeny. The importance of selecting for teat number is its relationship with other measures of performance which are of economic importance. The objectives of this study were to estimate heritability of teat number in a population of swine and to determine the effect of teat number on the various maternal traits.

Methods of Analysis

The data used in the present study were obtained over a 9-year period in a population of Minnesota No. 1 swine maintained at the North Central Experiment Station at Grand Rapids, Minnesota. Data were available for estimating heritability of teat number from a total of 353 litters with 108 sire groups represented. Performance data up through weaning were available on 302 of these litters.

Estimates of heritability of total teat number were obtained from a components of variance analysis and from the regression of offspring on dam. The analysis of variance used to estimate the sire and dam components of variance is given in table 1. A full-sib family mean was the statistical unit in this analysis. The following model was used to represent an observation on a full-sib family mean:

$$\overline{P}_{ij}=\mu+s_i+d_{ij}+\frac{1}{n_{ij}}\sum_k w_{ijk}$$

where

s_i=an effect common to all individuals from the i^{th} sire

d_{ij}=an effect common to all individuals from the j^{th} dam and the i^{th} sire

w_{ijk}=a residual effect that is variable from one individual to another within a full-sib family

n_{ij}=the number of individuals within the full-sib family

The variance arising from differences among individuals within full-sib families (W in table 1) was estimated from a separate analysis using individual observations. A smaller segment of the data was used in this analysis since the structure of the population makes it possible to estimate W with more precision than either the sire or dam component of variance. The sire component of variance was used as an estimate of one-fourth the additive genetic variance. Heritability was estimated from the paternal half-sib correlation.

The dam-offspring regression analysis was computed from the regression of average teat number in the offspring on total teat number in the dam. All analyses of variance and the regression analysis were computed on an intra-farrowing season basis with the cor-

TABLE 1. ANALYSIS OF VARIANCE AND EXPECTED MEAN SQUARES

Source of variation	d.f.	Expected mean square
Among sires	s−1	k_2W+D+k_3S
Among dams within sires	N−s	k_1W+D

$$k_1=\frac{1}{N-s}\left(\sum_i\sum_j\frac{1}{n_{ij}}-\sum_i\frac{1}{n_i}\sum_j\frac{1}{n_{ij}}\right).$$

$$k_2=\frac{1}{s-1}\left(\sum_i\frac{1}{n_i}\sum_j\frac{1}{n_{ij}}-\frac{1}{N}\sum_i\sum_j\frac{1}{n_{ij}}\right).$$

$$k_3=\frac{1}{s-1}\left(N-\frac{\sum n_i^2}{N}\right).$$

s=number of sires.
n_i=number of dams mated to the j^{th} sire.
n_{ij}=number of offspring from the j^{th} dam and i^{th} sire.
N=total number of dams.
S=variance due to differences among sires.
D=variance due to differences among dams.
W=variance due to differences among full-sibs.

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[2] The authors are indebted to the late August B. Salmela, Animal Husbandman at the North Central Experiment Station at Grand Rapids and Louis Hanson, Herdsman, for collection of the data.

TABLE 2. AVERAGE TEAT NUMBER OF DAMS AND OFFSPRING AND PERCENT OF DAMS WITH INSUFFICIENT TEATS

Farrowing season	No. of litters	Teat number: Dams average		Offspring average	No. pigs born alive	Percent dams with insufficient teats	
		Total	Functional			Total	Functional
Spring 51	19	14.2	9.6	13.6	10.5	15.8	57.8
Fall 51	19	14.4	10.3	13.1	10.1	10.5	36.8
Spring 52	37	13.8	10.2	13.6	10.2	10.8	35.1
Fall 52	19	14.0	10.4	13.5	11.0	5.2	42.0
Spring 53	39	13.7	10.8	13.6	9.2	0.0	23.1
Spring 54	39	13.7	10.9	13.6	11.4	10.3	41.0
Spring 55	32	13.5	11.0	13.6	9.0	0.0	18.8
Spring 56	37	13.8	11.1	13.7	9.4	2.8	13.9
Spring 57	39	13.5	11.0	13.5	10.1	5.1	25.6
Spring 58	35	13.4	11.1	13.6	9.9	4.0	12.0
Spring 59	38	13.3	11.3	13.3	10.2	2.9	14.7
Total	353	13.8	10.7	13.5	10.1	5.6	27.5

rected sums of squares and cross-products then pooled for all farrowing seasons.

Regression coefficients were obtained for number of pigs born alive, average birth weight, number of pigs weaned, average weaning weight, and total pounds of pigs weaned per litter on total teat number and functional teat number in the dam. Partial regression coefficients were obtained for these same maternal traits with the effect of number of pigs born alive being held constant. In these analyses total teat number refers to the number of visible teats at birth while functional teat number is the number of teats with milk at the time of farrowing.

Results and Discussion

It is apparent that the only need for using teat number as a criterion for selection is to insure that females have an adequate number of functional teats to raise the young pigs. In the Minnesota No. 1 population, only 5.6% of the dams had fewer total teats than number of pigs born alive and 27.5% of these dams had fewer functional teats than number of pigs born alive. The average number of pigs farrowed alive was 10.1 over the 9-year period. These results are summarized by farrowing season in table 2.

The phenotypic correlation between total teat number and functional teat number was estimated at 0.44 based on 291 degrees of freedom. This indicates that total teat number as determined at birth is not a good indication of the number of teats that will be functional at the time of farrowing.

The average total teat number in the Minnesota No. 1 population is high and compares favorably with the average teat number of 13.45 in the Landrace population reported by Allen *et al.* (1959). The frequency distribution for total teat number is shown in figure 1. The standard deviation of 0.84 in the Minnesota No. 1 is only slightly lower than the average of the Landrace. Poland and Duroc populations studied by Allen *et al.* (1959).

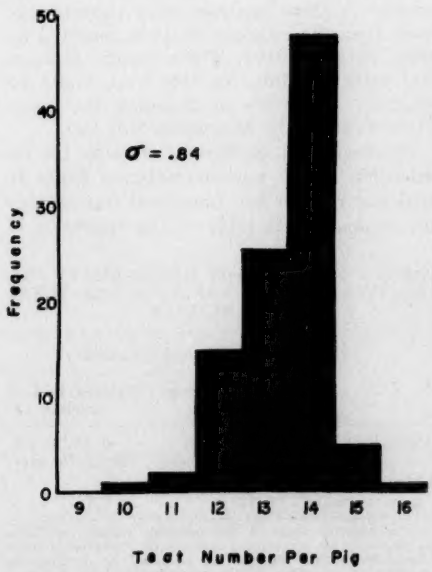

Figure 1. Frequency distribution (%) of teat numbers in the Minnesota No. 1 breed.

Estimates of heritability and additive genetic variance from the two methods of analysis are given in table 3. The components of variance estimates from which the paternal half-sib correlation was computed and the corresponding degrees of freedom associated with the estimates are as follows:

Component	Estimate	d.f.
S	0.04	98
D	0.07	225
W	0.58	1471

where S, D, and W are the sire, dam and within full-sib family components.

The estimate of additive genetic variance obtained from doubling the covariance between dam and offspring will be biased downward if selection has been practiced for teat number so that the phenotypic variance among the dams is less than the entire population. A comparison of the variation in the dams with the entire population showed that the phenotypic variance was actually larger among the dams than the population from which they were selected. The standard deviation among dams within farrowing seasons was 1.02 as compared with 0.84 for the entire population. An examination of the data showed that much of this additional variation in the dams could be attributed to the use of two sows with only 10 teats.

The estimates of heritability for total teat number in these analyses were considerably lower than the estimate of 0.386 reported by Allen *et al.* (1959). These results indicate that mass selection for this trait would be relatively ineffective in changing the population mean in the Minnesota No. 1's.

The regression coefficients showing the relationship of the various maternal traits to total teat number and functional teat number are summarized in table 4. The regression of number of pigs weaned, average weaning weight and pounds of pig weaned on total teat number were positive in each case but not significantly different from zero. The small effect of total teat number on the performance trait are in general agreement with the work of Phillips *et al.* (1945) in their work with sheep, Goertzen and Ibsen (1951) in their studies with guinea pigs, and Korkman (1947) with swine. Allen *et al.* (1959) reported a significant but small correlation between teat number and pigs per litter at birth. All other correlations were not significant.

TABLE 3. ESTIMATES OF HERITABILITY AND ADDITIVE GENETIC VARIANCE FOR TOTAL TEAT NUMBER

	Method of analysis	
	Dam-offspring regression	Paternal half-sib correlation
Heritability	0.10±0.04 (342 df. for dams)	0.23±0.20[a] (98 d.f. for sires)
Additive genetic variance[b]	0.11	0.16

[a] The standard error of the paternal half-sib correlation was estimated by the method outlined by Dickerson (1960).
[b] Additive genetic variance was estimated by doubling the dam-offspring covariance in the regression analysis and from four times the sire component of variance in the analysis of variance.

TABLE 4. REGRESSION OF VARIOUS MATERNAL TRAITS ON TOTAL TEAT NUMBER AND FUNCTIONAL TEAT NUMBER

	Regression coefficients[a]	
Maternal trait	Total teat number	Functional teat number
Number of pigs born alive	0.00± .14	0.43± .10
Average birth weight	0.00± .02	−.02± .02
	0.00± .03	0.00± .02
Number of pigs weaned	0.24± .14	0.61± .08
	0.20± .13	0.27± .09
Average weaning weight	0.19± .32	−.40± .23
	0.21± .32	−.21± .23
Total pounds of pig weaned	9.44±6.75	24.43±4.04
	8.17±5.93	11.70±4.00

[a] The second regression value in each case is a partial regression coefficient removing the effect of number of pigs born alive.

In every case the regression of the performance traits on functional teat number was larger in absolute magnitude than the corresponding regression on total teat number. It was thought that this may have been the result of an unconscious bias in counting since functional teat number was not determined until after the sow had farrowed. Removing the effect of number of pigs born alive did reduce the magnitude of the regression of all of the performance traits on functional teat number. A significant relationship still existed, however, between functional teat number and number of pigs weaned as well as total pounds of pig weaned.

The regression coefficients given in table 4 may all be biased slightly downward because of some transferring of pigs. The records were not such that these litters could be eliminated from the analysis. The results that are presented, however, may reflect more accurately the relationships that exist under practical swine husbandry conditions where some trans-

ferring is feasible. Under these conditions it appears that the low heritability of teat number combined with the small relationship of teat number to maternal performance would make it impractical to attempt to improve performance of the maternal traits by selecting for teat number.

Summary

The estimates of heritability of total teat number obtained in a population of Minnesota No. 1 swine were 0.10±0.04 from the dam-offspring regression analysis and 0.23 ±0.20 from the paternal half-sib correlation. The regressions of various maternal traits on total teat number were small and statistically non-significant for the traits considered. Significant regression values of 0.27 and 11.70 were found for the regression of number of pigs weaned and pounds of pig weaned on functional teat number after removing the effect of number of pigs born alive.

Literature Cited

Allen, A. D., L. F. Tribble and J. F. Lasley. 1959. Inheritance of nipple numbers in swine and relationship to performance. Mo. Agr. Exp. Sta. Res. Bul. 694.

Dickerson, G. E. 1960. Techniques for research in quantitative animal genetics. Techniques and Procedures in Animal Production Research. American Society of Animal Production.

Goertzen, B. L. and H. I. Ibsen. 1951. Super-numerary mammae in guinea pigs. J. Heredity. 42:307.

Korkman, N. 1947. Causes of variation in the size and weight of litters from sows. Acta. Agr. Suecana. 2:253.

Phillips, R. W., R. G. Schott and D. A. Spencer. 1945. The genetics, physiology and economic importance of the multinipple trait in sheep. U.S.D.A. Tech. Bul. 909.

LYSINE SUPPLEMENTATION IN RATIONS FOR SHEEP

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THE results of Loosli *et al.* (1949), McDonald (1954) and Weller (1957) indicate that the amino acid lysine is synthesized readily by rumen microflora thus it is not considered a dietary essential in ruminant rations. The recent results of Hale *et al.* (1959), using cattle and sheep, indicate that rate of lysine synthesis could be a rate-limiting step influencing gains of ruminants; cattle receiving a low-protein diet (8.6% crude protein) grew at a slow rate and lysine supplementation did not influence gains; however, when the level was increased to 11.6% crude protein, gains were increased and lysine supplementation further increased gains by 15%. Later results by Perry *et al.* (1960) indicated that the addition of lysine to the diets of steers fed fattening-type rations containing urea also increased the rates of gain. It thus appeared desirable to determine the effect of supplemental lysine upon gains of sheep fed diets of varying compositions.

Experimental Procedure

First Trial. As the first limiting amino acid in the various sorghum grains and expeller-processed cottonseed meal is lysine, the diets employed in this trial were deficient in this amino acid. The composition of the basal diet in percent was: cottonseed hulls, 10.0; alfalfa meal, 10.0; cane molasses, 5.0; ground milo, 69.3; expeller processed cottonseed meal, 5.0; urea, 0.20; sodium chloride, 0.25; calcium carbonate, 0.20; vitamins A and D, 0.05; and contained 11.8% protein. The experimental diet contained, in addition, 445 mgm. of L-lysine monohydrochloride/lb. feed.

Twenty lambs weighing initially an average of 76 lb. each were divided on the basis of weight into two balanced groups and individually-caged and -fed the rations for the 45-day trial. The animals were weighed initially and at 15-day intervals during the test. A 16-hour shrink period, during which time feed and water were not available, preceded the initial and final weights.

Second Trial. Lysine was added to a purified diet for sheep in which all the ration nitrogen was supplied by crystalline urea. The compositions of the diets are shown in table 1. Ten Dorset x Western wethers averaging about 49 lb. each were randomly divided into two groups of five each. The animals were individually-caged and -fed during the 50-day feeding trial. The animals were weighed initially and at 14-day intervals during the trial except only 10 days separated the third and final periods. A 16-hour shrink period, during which neither feed nor water was available, preceded the initial and final weights.

Results and Discussion

The results of Trials 1 and 2 are shown in table 2 and it is evident that lysine supplementation was not beneficial in either trial. These results do not confirm those of Hale *et al.* (1959) and it is of interest to compare experimental conditions used in the two laboratories in an attempt to explain the divergent results. Their sheep ration contained, in percent: ground corn, 53.5; sun-cured alfalfa meal, 35.0; molasses, 7.0; urea, 1.0; steamed bone meal, 1.0 and bentonite, 2.5. The rations contained 11.5% crude protein and was pelleted while in the present experiment the ground products were mixed with the somewhat bulky cottonseed hulls and fed in that form. As rate of food passage through the gastrointestinal tract, methane production (Blaxter and Graham, 1956) and proportion of volatile fatty acids (Ensor *et al.*, 1959; Shaw *et al.*, 1960) are altered by the pelleting process, the possibility of altered microbial fermentation must be considered as a factor. Their sheep gained only 0.32 and 0.43 lb. daily when consuming, respectively, the basal and lysine supplemented basal diet, thus rate of gain is not a consideration. Also supplemental lysine levels were similar, but their diets contained more urea than did ours. Perry *et al.* (1960) found that when lysine

[1] Department of Animal Husbandry.
[2] Approved by the Director.

TABLE 1. PERCENT COMPOSITION OF THE PURIFIED DIETS

Ingredient	Ration 1	Ration 2
Starch	23.60	23.52
Dextrose	23.60	23.52
Cellulose[a]	40.00	40.00
Urea[b]	4.20	4.16
Corn oil	1.00	1.00
Vitamins A and D[c]	0.10 gm. per lb. ration	
Polyethylene resin[d]	1.00	1.00
Choline chloride	0.10	0.10
L-lysine-HCl	....	0.20
Minerals[e]	6.50	6.50

[a] Solka-Floc. Brown Co., Berlin, N. H.
[b] Crystalline urea—Courtesy John Deere Chemical Co., Pryor, Oklahoma.
[c] Quadrex. 20,000 I.U. vitamin A and 2,500 USP vitamin D_3/gm. Courtesy NOPCO Chemical Co., Harrison, N. J.
[d] Alathon, E. I. DuPont de Nemours, Inc., Wilmington, Del.
[e] Mineral mixture of the following percentage composition:

K_2CO_3	31.55	$Na_2B_4O_7$	0.19
$CaHPO_4$	48.94	$CuCO_3$	0.02
$MgSO_4$	10.75	$ZnSO_4$	0.07
NaCl	7.43	$CoCl_2$	0.0003
$FeSO_4$	0.91	KI	0.03
$MnSO_4$	0.10	MoO_3	0.0008

was added to diets of cattle receiving protein supplements containing 0.0, 3.7, 7.4, 11.1, 14.8 and 18.5% urea, gains were increased in all of the urea-containing diets. Later work by Beeson *et al.* (1961) in the same laboratory, however, failed to confirm the results of Perry *et al.* (1960) when a protein supplement, which contained 14.8% urea, was supplemented with two levels of lysine. As the conditions under which the two experiments were conducted appeared to be almost identical, interpretation of these results are difficult.

Because of the divergent and confusing results found when natural diets for ruminants are supplemented with lysine it was decided to determine the effects of lysine when added to a purified diet in which crystalline urea was the nitrogen source. It appeared possible that the increased gains obtained when using the present purified diet could increase the lysine needs above the level synthesized in the rumen thus lysine supplementation could result in increased rates of gain. The results of the second trial do not lend support to this idea and are in agreement with those reported by Meacham *et al.* (1961). As the results of many workers (Loosli *et al.*, 1949; McNaught, 1952; Agrawala *et al.*, 1953; McDonald, 1954; Duncan *et al.*, 1953; Weller, 1957) indicate that lysine is readily synthesized by rumen microflora, it would appear that no beneficial effects should be expected when lysine is added to ruminant diets unless rumen fermentation is greatly decreased.

Summary

Adding 445 mg. of L-lysine-HCl/lb. diet to a high-energy diet composed primarily of milo and cottonseed meal did not result in a significant effect on gains or efficiency of gains in sheep. Lysine supplementation did not have a significant effect on gains of sheep receiving a purified diet in which the nitrogen source was crystalline urea.

Literature Cited

Agrawala, I. P., C. W. Duncan and C. F. Huffman. 1953. A quantitative study of rumen synthesis in the bovine on natural and purified rations. I. Protein, dry matter and non-protein nitrogen. J. Nutr. 49:29.

Beeson, W. M., T. W. Perry, W. H. Gosset, M. T. Mohler and M. P. Plumlee. 1961. Lysine, methionine analog and trace mineral additions to a 64 percent protein-urea supplement for fattening beef steers. Purdue University Agr. Exp. Sta. Mimeo AS–293.

Blaxter, K. L. and N. McC. Graham. 1956. The effect of the grinding and cubing process on the utilization of the energy of dried grass. J. Agr. Sci. 47:207.

Duncan, C. W., I. P. Agrawala, C. F. Huffman and R. W. Luecke. 1953. A quantitative study of rumen synthesis in the bovine on natural and purified rations. II. Amino acid content of mixed rumen proteins. J. Nutr. 49:41.

Ensor, W. L., J. C. Shaw and H. F. Tallechea. 1959. Special diets for the production of low fat milk and more efficient gains in body weight. J. Dairy Sci. 42:189.

Hale, W. H., W. C. Sherman, W. M. Reynolds and P. P. Appel. 1959. Studies on lysine in cattle and lamb nutrition. J. Animal Sci. 18:1522. (Abstr.).

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TABLE 2. THE EFFECT OF SUPPLEMENTAL LYSINE UPON SHEEP WEIGHT GAINS

Trial number	Diets	Final weight	Initial weight	Average daily gains	Feed/lb. gain
		lb.	lb.	lb.	lb.
I.	Milo	99.4	76.0	0.52±0.08[a]	7.01±0.50
I.	Milo plus lysine	99.0	76.0	0.51±0.09	7.04±0.49
II.	Purified	63.0	49.0	0.28±0.06	10.70±1.47
II.	Purified plus lysine	63.0	49.0	0.28±0.02	8.80±0.58

[a] Standard error.

Ferris and L. A. Maynard. 1949. Synthesis of amino acids in the rumen. Science 110:144.
McDonald, I. W. 1954. The extent of conversion of food protein to microbial protein in the rumen of the sheep. Biochem. J. 56:120.
McNaught, M. L. 1952. The synthesis of lysine by bacteria during incubation of rumen contents *in vitro*. Biochem. J. 50:i. (Abstr.).
Meacham, T. N., T. J. Cunha, A. C. Warnick, P. E. Loggins and J. F. Hentges, Jr. 1961. Growth and feeding performance of young rams fed various purified rations. J. Animal Sci. 20:387. (Abstr.).
Perry, T. W., W. M. Beeson and W. T. Mohler. 1960. High protein-urea supplements with and without lysine for fattening steer calves. Purdue University Agr. Exp. Sta. Mimeo AS–277.
Shaw, J. C., W. L. Ensor, H. F. Tellechea and S. D. Lee. 1960. Relation of diet to rumen volatile fatty acids, digestibility, efficiency of gain and degree of unsaturation of body fat in steers. J. Nutr. 71:203.
Weller, R. A. 1957. The amino acid composition of hydrolysates of microbial preparations from the rumen of sheep. Australian J. Biol. Sci. 10:384.

EFFECT OF GRAZING MANAGEMENT ON BODY WEIGHT AND SUBSEQUENT WOOL AND LAMB PRODUCTION OF NON-LACTATING EWES [1]

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THE market price for spring lambs often reaches its peak during late May and early June. This is encouraging an increasing number of sheepmen to creep-feed their early lambs. These lambs often weigh 70–80 lb. in early May when grass becomes available. They may be weaned at 10–14 weeks of age and fed in drylot with no decrease in subsequent gains (Jordan *et al.*, 1959; Baird *et al.*, 1960). The ewes are usually turned out to pasture following weaning. Since these ewes lactate only 10–14 weeks, the period from lactation until breeding is considerably longer than that of ewes that lactate 20–24 weeks. For the program of "early weaning" to be most successful every effort should be made to reduce the feed requirements of maintaining the non-lactating ewe during the summer months.

The objectives of this study were: (1) to develop a grazing scheme that would increase the number of dry ewes pastured per acre, and (2) to prevent dry ewes from becoming excessively fat during the grazing season.

Methods

During the summers of 1959 and 1960, six separate pastures, each 0.7 acre in size, with vigorous stands of bromegrass (*Bromus inermis*) and quackgrass (*Agropyron repens*) were used for this study. Ammonium nitrate fertilizer was broadcast over each pasture in mid-April at a rate of 40 lb. of nitrogen per acre in 1959 and 100 lb. of nitrogen per acre in 1960. A portable shade, a mineral box for salt and minerals and a source of fresh water were available in each pasture.

The three replicated treatments were as follows: heavy-stocked continuous grazing (HC)—10 ewes each in pastures 1 and 4, allowed to graze continuously; light-stocked continuous grazing (LC)—five ewes in each of pastures 2 and 5, allowed to graze continuously; and restricted-time grazing (RT)—10 ewes in each of pastures 3 and 6, allowed to graze on a restricted-time basis.

The amount of time per week that ewes in pastures 3 and 6 (RT) were allowed to graze was restricted by confining them in small corrals that had been constructed within the pastures. The portable shades, mineral and salt box, and source of water were within the corrals. The confinement began at noon when the ewes were normally under the shades. The grazing and confinement periods for a 1-week period on the RT treatment were as follows: the ewes grazed 68 hours, were confined 52 hours, allowed to graze for 20 hours, and were confined for 28 hours.

In 1959, 2-year-old western white-faced ewes and, in 1960, mature Hampshire and Shropshire ewes, that had suckled lambs for 12 weeks prior to the beginning of the experiment, were used as test animals. During the lactation period all of the ewes had been fed alfalfa hay *ad libitum* and 1 lb. of shelled corn per ewe daily. The ewes were in good-to-moderate flesh at the time their lambs were weaned and at the initiation of the experiment.

Ewes were allotted to treatment from outcome groups based on weight in 1959, and on weight and breed in 1960. Individual weights were obtained periodically through the grazing season. In 1959, ewe weights were obtained on Monday, Wednesday, Thursday and Friday during a 1-week period to determine the magnitude of the body weight changes following periods of grazing and confinement. The data were analyzed by analysis of variance. Grazing began on May 15, 1959 and on May 5, 1960.

In 1959, the stocking rate per pasture remained constant throughout the entire trial. In 1960, it became apparent that greater

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stocking pressure should be exerted in an attempt to show more clearly the difference in carrying capacity as affected by the management of the sheep. Therefore, four additional ewes were added to each of pastures 3 and 6 (RT), two ewes to pastures 1 and 4 (HC), and one ewe to each of pastures 2 and 5 (LC) on July 17.

Upon completion of the experimental grazing period all of the ewes were managed in one band. They grazed bromegrass during the breeding season and were fed alfalfa-bromegrass hay and corn silage during the gestation period. No further ewe weights were obtained. Birth weights of the lambs were obtained both years and lamb weights at about 3 weeks of age the first year. Due to a long lambing season the second year no measure of lamb growth was obtained.

Duplicate cage clippings and swath samples were obtained from each replicate each year as an added method of measuring forage utilization. Due to extreme overgrazing in 1959, little or no forage could be harvested in the HC pastures after the first month of grazing. Forage consumption, therefore, could not be determined during that period.

Results and Discussion

The effect of the treatments on body weight changes during the experimental period and data on fleece weights and lamb production for both years are presented in table 1. Using Duncan's (1955) multiple range test, it was determined that the difference in body weight changes between the restricted-time grazing (RT) treatment and the light-stocked continuous grazing (LC) treatment was significant at the 1% level. There was no significant difference in weight gains between the LC and the heavy-stocked continuous grazing (HC) treatments or the HC and RT treatments.

Ewes grazing continuously at either the high- or low-stocking rate increased in body weight for the first 30 to 60 days of the experimental period. Conversely, restricting the grazing time resulted in an appreciable weight loss during the first month with the decline in weight leveling off during the latter ⅓ of the grazing period. These two general patterns of weight change were observed in all replications during both years.

During a 1-week period in 1959 ewes on RT treatment were weighed before and after each confinement. The ewes lost 8 to 10 lb. after 2¼ days of confinement and 5 to 7 lb. following 1-day confinement. However, following a day of grazing, this weight loss was largely regained. The fasting periods appeared to cause the ewes little distress. When returned to pasture at 4 p.m., they started grazing regardless of the environmental temperature which occasionally reached 90–95° F. This tendency to eat their fill following a period of confinement indicates that this method of pasture management could not be used with forages that caused bloat.

TABLE 1. EFFECT OF GRAZING MANAGEMENT ON NON-LACTATING EWES [a]

Stocking rate Grazing time	Heavy Restricted	Heavy Continuous	Light Continuous
1959—82 days			
No. ewes	20	20	10
Initial wt., lb.	114.9	115.8	113.3
Weight change, lb.[b]	—3.7	0.9	12.6
Fleece wt., lb.	9.4	9.3	10.2
Lamb crop, % [c]	142	150	160
No. ewes not lambing	1	0	0
Lamb birth wt., lb.	11.2	11.0	10.4
Lamb wt. at 3 weeks, lb.	20.0	19.7	21.7
Ewe grazing days per acre	1172	1172	586
1960—97 days			
No. ewes	20	20	10
Initial wt., lb.	136.3	135.1	130.5
Weight change, lb.[b]	—16.2	—2.2	8.9
Fleece wt., lb.	7.5	7.8	7.9
Lamb crop, % [c]	156	170	175
No. ewes not lambing	2	0	1
Lamb birth wt., lb.	10.0	10.2	9.9
Ewe grazing days per acre			
Testers	1386	1386	693
Grazers	160	80	40
Total	1546	1466	733

[a] Average of two replications per treatment each year.
[b] Means not joined by a common underline are significantly different.
[c] Based on only those ewes that lambed. One ewe died during the winter (1960–61) in the light continuous treatment.

Wool production, weight of lambs at birth, 3-week lambing weights and lambing percentage were not significantly different between treatments. Since the grazing treatments lasted for only about 3 months it is possible that managing all treatment groups as one band of ewes during the breeding and gestation period may have masked the effects of the grazing treatments.

An accurate measure of forage consumption by grazing sheep based on forage production and residual forage proved to be difficult. In 1959, no measurable amount of residual forage could be collected from the HC treat-

TABLE 2. APPARENT AVAILABLE FORAGE PRIOR TO GRAZING, RESIDUAL FORAGE FOLLOWING GRAZING AND CONSUMPTION ESTIMATES FOR EWES GRAZED UNDER THREE MANAGEMENTS IN 1959 AND 1960 [a]

Grazing management	Year	Available forage prior to grazing	Total forage production [b]	Residual forage remaining at end of period [c]	Apparent consumption	Daily consumption per ewe of D.M.
		Tons of D.M./acre				lb.
Heavy, continuous	1959	0.49	0.87	0.34	0.53	3.53
	1960	0.16	2.63	0.03	2.60	3.55
Heavy, restricted	1959	0.44	1.07	0.59	0.48	3.20
	1960	0.18	2.59	0.37	2.22	2.87
Light, continuous	1959	0.39	1.08	0.70	0.38	5.07
	1960	0.19	2.74	0.43	2.31	6.32

[a] 1959 figures include only period from May 15 to June 5 as overgrazing in heavy continuous and underestimation in all treatments invalidated the estimation of consumption values beyond that date.
1960 figures include: Period 1—5/5 to 6/17; Period 2—6/18 to 7/19, and Period 3—7/19 to 8/5.
[b] Determined by protected duplicate cages in two replicates.
[c] Determined by duplicate mower swath samples of the grazed area (1.5 in. height) in two replicates.

ment. However the ewes remained in good condition because they grazed the new growth before it became tall enough to mow.

Apparent forage consumption (table 2) as determined by the difference between total forage production and residual forage at the end of the grazing period indicates that the system of grazing did reduce forage intake. In 1960, forage consumption obtained for the entire grazing season averaged 3.55, 2.87 and 6.32 lb. of dry matter per ewe daily for the HC, RT and LC treatments, respectively. A similar though less pronounced pattern was evident during the first grazing period in 1959.

The most striking aspect of the trial was the difference in amount of available forage remaining in different pastures during the grazing season. For example, at the beginning of the grazing period in 1959, the HC pastures had 0.49 ton, the RT pastures had 0.39 ton and the LC pastures had 0.44 ton of dry matter per acre. On June 5, 1959, 0.34 ton, 0.59 ton and 0.70 ton of dry matter remained in the HC, RT and LC pastures, respectively. At the end of the grazing season 0.12 ton dry matter per acre remained in the LC pastures, 0.09 ton of dry matter per acre remained in the RT pastures and no harvestable dry matter remained in the HC pastures.

The same general pattern was evident during the grazing season of 1960. For example, on May 5 there was about the same amount of forage per acre in each treatment (table 2). On June 17 and July 19 the HC pastures contained 0.46 and 0.61 ton, respectively, the RT pastures contained 0.53 and 1.02 ton and the LC pastures contained 1.19 and 1.03 tons per acre. At the end of the grazing season 0.03 ton, 0.37 ton and 0.43 ton of dry matter per acre remained in the HC pastures, RT pastures and LC pastures, respectively.

Summary

This study on the effect of limiting the amount of time non-lactating ewes are allowed to graze involved three pasture treatments and 100 ewes during a 2-year period. Ewes were grazed continuously at either 7 or 14 ewes per acre, or on a restricted time basis at 14 ewes per acre.

Restricting grazing time to about 52% of normal resulted in greater weight loss of the ewe but had no significant effect on wool or lamb production. This system of grazing reduced forage consumption as determined by protected cage samples and swath clipping samples and increased carrying capacity per acre.

Literature Cited

Baird, D. M., H. C. McCampbell, W. E. Nevill, H. Ciordia, W. E. Bizzell and O. E. Sell. 1960. Milk and forage consumption, growth, carcass characteristics and parasitism of early- vs. late-weaned lambs on winter temporary pastures. J. Animal Sci. 19:1302.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics 11:1.

Jordan, R. M., H. E. Hanke and D. E. Reimer. 1959. The early weaning of lambs. Feedstuffs 31:86.

EVALUATION OF ANNUAL CROPS AS PASTURE FOR EARLY-WEANED LAMBS[1]

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REPORTS of sheep grazing trials with annual forage crops are limited but there is considerable literature on the yields of these crops as measured in clipped plots. Odland (1942) has reviewed the adaptations of various annual crops for grazing. In actual grazing trials, Dorrance (1931) reported a carrying capacity of 360 days per acre for sheep on Sudangrass (*Sorghum sudanense*) while rape (*Brassica napus* var. biennis), Dwarf Essex variety, supplied 158 days. All sheep were in approximately the same condition following the trial. An Ohio report by Hammond (1920) cited that an acre of rape pasture produced as much gain on fattening lambs as 3½ acres of "fairly good bluegrass, *Poa pratensis*". Wilson and Kuhlman (1924) compared "lambing off" of corn (*Zea mays*) with rape pasture. Lambs in the cornfield started at 60 lb. and gained 0.42 to 0.49 lb. daily while those on rape gained 0.34 to 0.37 lb.

The study reported herein deals with the adaptation of several common annual forages for sheep pasture. The grazing sequences were established to provide all summer pasture and were composed of one or two species in early-summer and late-summer groups. A report by Wedin (1961) has cited the relationships of harvest date to yield, crude protein and moisture percentage of these crops.

Experimental Procedure

The pastures were sown on Waukegan silt loam at Rosemount, Minnesota in 1958 and 1959. The treatments, with seeding rate per acre were: (1) all summer pasture—3 bu. of oats (*Avena sativa*) (Minhafer) and 6 lb. of rape (Dwarf Essex) sown together; (2) early-summer pasture—2.5 bu. of peas (*Pisum arvense*) (Yellow Canadian Fancy) followed by late-summer pasture—2.25 bu. of field corn (mixed maturities), "solid seeded" and (3) early-summer pastures—1.5 bu. of oats, 1.5 bu. of peas, sown together followed by late-summer pasture—45 lb. of Sudangrass (Piper).

All pastures were ⅓ acre in size by treatment. In treatments 2 and 3, where a grazing sequence was involved, the ⅓ acre unit was divided in half to accommodate the early to late-summer succession. Thus, the treatments were arranged in a randomized complete block design and the early and late-summer lots were randomized within each treatment. Each pasture was grazed continuously in five replicates. A sixth lot of each pasture treatment was utilized as a reserve pasture.

Fertility treatments prior to planting included 425 lb. of 5–20–20 per acre in 1958 and 300 lb. of 5–20–20 per acre in 1959. All seedings received 30 lb. of nitrogen per acre at seeding time excepting treatment 2: peas (none), corn (60 lb.).

Seeding dates for oats-rape, oats-peas and peas were April 18, 1958 and April 16, 1959. Sudangrass and corn were sown on May 26 each year. All plots were seeded with a conventional drill excepting in 1958 when corn and Sudangrass were broadcast.

Test animals used were early-weaned native lambs. At the initiation of the trial in 1958, the lambs were 12–14 weeks of age and weighed 52–55 lb. In 1959, the test animals were 14 weeks of age and averaged 65 lb. in weight. Fresh water and a salt-mineral-phenothiazine mixture were always available but no shade was provided.

Lambs were designated as testers and grazers with only the tester lambs being used for daily gain comparisons. The grazer animals were used in a "put and take" system such that stocking rate was adjusted each week based on combined judgments of an agronomist and animal husbandman. Grazing commenced on June 2 in both years and

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TABLE 1. AVERAGE STOCKING RATES, GRAZING PERIOD, DAILY GAIN AND LAMB DAYS FOR ANNUAL FORAGES PASTURED AT ROSEMOUNT, MINNESOTA. FIVE REPLICATES

Annual crops in pasture		Oats-rape	Peas	Corn	Oats-peas	Sudangrass
Stocking rate (lambs per acre)	1958	16	24	24	27	21
	1959	15	24	36	24	32
Average		15.5	24.0	30.0	25.5	26.5
Grazing period (days)	1958[a]	92	29	30	31	58
	1959	66	29	36	29	41
Average		79.0	29.0	33.0	30.0	49.5
Average daily gain (lb.)	1958[b]	0.45	0.42	0.48	0.48	0.41
	1959	0.32	0.21	0.31	0.30	0.23
Average		0.38	0.32	0.40	0.39	0.32
Lamb days per acre	1958	1472	696	720	837	1218
	1959	990	696	1296	696	1312
Average		1231	696	1008	766	1265

[a] Includes entire season's grazing to emphasize the availability of pasture. For total product per acre calculation, see table 2.
[b] Average daily gain value based on weights through July 17 only—explained in text.

extended into late-August, 1958, and mid-August, 1959.

Statistical differences among treatments were subjected to multiple range tests based on a q value of the studentized range from Pearson and Hartley (1954).

Results

Stocking Rate. Because of the temporary or emergency status generally ascribed to an annual pasture crop the stocking rate which it will maintain is of extreme importance. The average stocking rates over the 2-year period for each crop are given in table 1. Oats-peas pasture maintained slightly more lambs than peas alone in early summer while corn was superior to Sudangrass in this regard in late summer. When stocking rates are considered over the entire grazing season (table 2), however, it is evident that the average stocking rate per acre favored oats-rape. However, all seasonal combinations were in the range of 13 to 16 lambs per acre.

Grazing Period. The length of grazing period which each pasture crop (table 1) provides is another important criterion in evaluation of a temporary pasture crop. For early-summer grazing, crops were similar with respect to grazing period. Extended periods of grazing were found for Sudangrass over solid-seeded corn because of the recovery ability of Sudangrass following grazing.

Lamb Days per Acre. Consideration of the pasture crops individually on a lamb day per acre (table 1) basis revealed Sudangrass and oats-rape to be significantly greater than the other crops ($P<0.01$). Corn provided significantly more lamb days ($P<0.05$) than oats-peas or peas alone. When the crops were analyzed by treatments over the entire season (table 2) lamb days were significantly different ($P<0.01$) between each treatment in the following decreasing order: oats-rape, oats-peas followed by Sudangrass, peas followed by corn. The order and statistical significance of these treatments was similar in 1958 to the

TABLE 2. GRAZING COMBINATION (TREATMENT) AVERAGES FOR ANNUAL FORAGE CROP PASTURES AT ROSEMOUNT, MINNESOTA, 1958–1959. FIVE REPLICATES

Grazing combination of annual crops	Oats-rape	Peas to corn	Oats-peas to Sudangrass
Seasonal treatment averages			
Stocking rate (lambs per acre)	15.5	13.5	13.0
Grazing period (days)	79.0	62.0	79.5
Lamb days per acre	1231	852	1015
Animal product by treatment[a]			
Grazing period (days)	56.0	56.0	58.0
Average daily gain (lb.)	0.38	0.36	0.36
Lamb days per acre	824	794	809
Gain per acre (lb.)	313	286	291

[a] Does not include grazing days or animal gains after July 17 in 1958 due to failure in obtaining reliable weights after that date.

2-year average values. However, in 1959 less satisfactory stands of rape were overshadowed by excellent performance of Sudangrass and solid-seeded corn in the last half of the grazing season. Consequently, lamb days did not differ significantly in 1959 among the 3 treatments.

Animal Performance. A crucial test of pasture crop value relates to the performance of the grazing animals. When analyzed over the entire grazing season, the variety or species of forage did not have a significant effect on average daily gain. Moreover, the average daily gains of lambs pastured on oats-rape, oats-peas, and peas alone in early season were found not to be significantly different.

Animal Product per Acre. Oats-rape exceeded the other combinations over the 2-year period (table 2) in total lamb produced per acre. These differences are not as large as might be expected, however, on the basis of the animal performance and lamb days per acre. Failures to obtain reliable weights precluded the inclusion of animal performance beyond July 17 in 1958 and tend to bias the animal product results in table 2 against oats-rape. The excellent results with rape in 1958 following July 17, are not included whereas the poorer results with rape in 1959 are included.

Discussion

The crop combination allowing for most extended grazing on one land area and with one seeding is oats-rape. For desired periods of grazing for 2 months or more, this combination should be favored over the others tested.

The other emergency crops might best fit the stocking rates and length of grazing period desired in some cases. This might be particularly true for Sudangrass and corn which are largely available after July 1 when perennial pastures often fall short of providing needed forage. Such emergency pastures would serve to complete the fattening of lambs within 10–15 pounds of market weight. The importance of a full-season pasture program can not be under estimated, however.

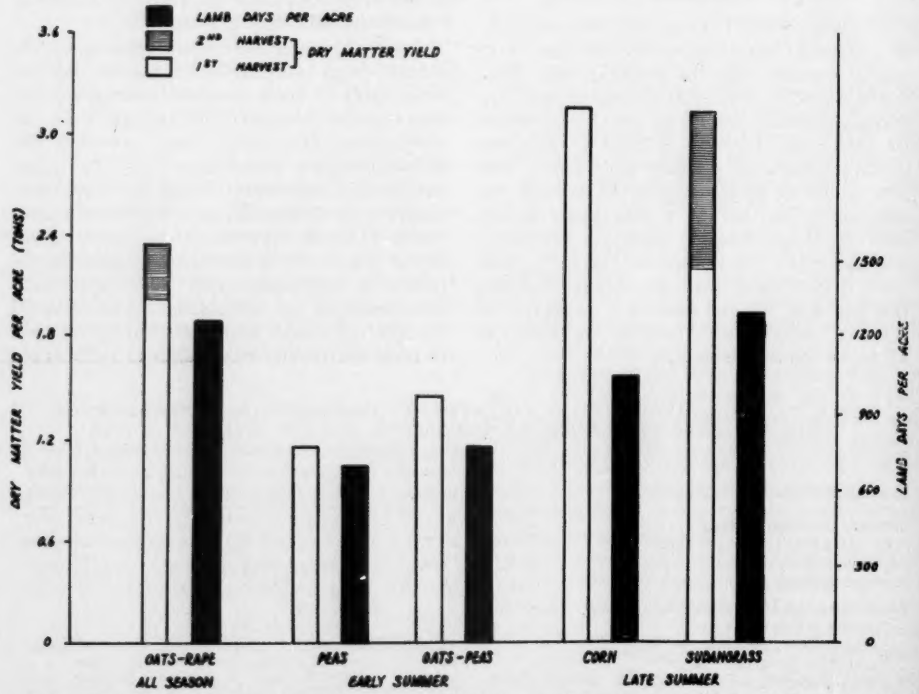

Figure 1. Yields of annual forage corps in tons of dry matter per acre with lamb days per acre obtained in grazing these crops with early-weaned lambs.

In an adjoining study, Wedin (1961) reported on yields of annual forage crops determined by clipping. When these yields are compared with total grazing days provided by the crops, considerable variation is shown (figure 1). It is evident that clipping yields as such tend to magnify the amounts of forage presumably useable by livestock. To estimate the potential performance of a specific crop under grazing from clipping yields alone can be both unwise and misleading.

Summary

Average total gain in pounds of lamb per acre for three combinations of annual crops were: oats-rape, 313; peas followed by corn, 286; oats-peas followed by Sudangrass, 291. Oats-rape provided the most suitable summer pasture for the longest period; oats for early grazing while the less palatable rape was available later. Sudangrass also performed well under grazing while oats-peas, peas and corn were satisfactory for short periods. Solid-seeded corn supported very high stocking rates. Yields from clipped plots of annual crops should not be used to estimate the grazing periods, stocking rates or total gains which might be obtained under grazing.

Literature Cited

Dorrance, A. B. 1931. Sudan is a valuable pasture crop in Michigan. Mich. Agr. Exp. Sta. Quart. Bul. 13.

Hammond, J. W. 1920. Green forage crops and corn for fattening lambs. Ohio Agr. Exp. Sta. Bul. 340.

Odland, T. E. 1942. Adaptation of various crops for supplementary pasture. J. Am. Soc. Agron. 34:229.

Pearson, E. S., and H. D. Hartley. 1954. Editors of "Biometrika tables for statisticians". University Press, Cambridge 1:176.

Wedin, W. F. 1962. Yield and percentages of crude protein and moisture of several annual forage crops as affected by harvest date. Agron. J. (in press.)

Wilson, J. W., and A. H. Kuhlman. 1924. Forage crops for lambs. S. D. Agr. Exp. Sta. Bul. 207.

SWINE HEMATOLOGY FROM BIRTH TO MATURITY. II. ERYTHROCYTE POPULATION, SIZE AND HEMOGLOBIN CONCENTRATION [1]

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RECENT interest in normal measures of swine erythrocyte population, size and composition has accrued from the need for critical assays of the efficacy of anti-anemia preparations. Such information is equally valuable for comparative purposes in studies of the effects of nutrient deficiencies, disease and x-ray or gamma-ray radiation on the hemopoietic system.

Excellent reviews of the literature have been made by Calhoun and Smith (1958) and Weide and Twiehaus (1959). Many other studies have been made concerning the effects of nutrition, disease and environment upon the cellular and plasmal constituents of the blood of swine over relatively short age spans.

A previous study in this series (Miller *et al.*, 1961) has dealt with changes in swine serum proteins from birth to maturity. The present study was conducted to establish normal values of the erythrocyte and reticulocyte population as well as the size and hemoglobin concentration of the erythrocytes of the blood of swine utilizing a large number of animals at frequent intervals from birth to maturity.

Experimental Procedure

Animals used in this study were purebred Durocs, Hampshires, Yorkshires, Berkshires or crossbreds reared at the Michigan State University swine research farm. Pigs were farrowed and reared in confinement. At 3 days of age all pigs received an intramuscular injection of iron-dextran containing either 100 or 150 mg. of elemental iron. A dry prestarter diet was made available in a creep to the pigs at 1 week of age. Male pigs were castrated at 4 weeks and all pigs were weaned at 5 to 6 weeks of age. After weaning the pigs received typical natural dry meal rations to slaughter age (5 or 6 months) or to maturity (females). All pigs received cholera vaccinations at 7 or 8 weeks of age. Gilts were bred to farrow at one year of age.

A total of 3678 blood samples were obtained from the anterior vena cava or an ear vein at frequent age intervals. Erythrocyte and reticulocyte enumerations were performed on many of the samples while only hemoglobin and hematocrit determinations were made on all samples. All determinations were performed as previously described by Ullrey *et al.* (1959).

Results and Discussion

The mean values of erythrocyte population, percentage of reticulocytes, blood hemoglobin, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration of male and female swine in the study are presented in tables 1 and 2. Graphical plots of these measures using the combined data from both sexes are shown in figure 1. No attempt was made to summarize the data according to breeds because of the small number of animals of some of the breeds at many of the age intervals.

Inspection of the data reveals that swine reared under the management conditions prevailing in this study tend to develop anemia on two occasions in early life. One occurs shortly after birth following the consumption of colostrum which provides an increase of serum proteins (Miller *et al.*, 1961) with a concomitant increase in plasma volume and a dilution of the circulating cellular components (McCance and Widdowson, 1959). This trend is quickly reversed, initially perhaps by the action of an increased titer of erythropoietin which may be released from the kidney (Jacobsen *et al.*, 1957) under the influence of a relative anemic hypoxia combined with an increased oxygen need by the animal (Jacobsen *et al.*, 1956). This results in an

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TABLE 1. COMPARISONS OF BLOOD HEMOGLOBIN, HEMATOCRIT AND MEAN CORPUSCULAR HEMOGLOBIN CONCENTRATION IN MALE AND FEMALE SWINE

Age	Number of animals		Hemoglobin, gm./100 ml.		Hematocrit, %		MCHC, %	
	Male[a]	Female	Male	Female	Male	Female	Male	Female
Birth	60	61	12.6±0.2[b]	12.5±0.2	39.8±0.5	40.3±0.7	31.6±0.2	31.3±0.2
1 day	203	161	11.3±0.2	11.5±0.2	37.6±0.5	38.2±0.5	30.2±0.2	30.2±0.2
2 days	49	44	9.7±0.2	10.3±0.2*	32.5±0.9	34.1±0.7	30.4±0.5	30.5±0.6
3 "	203	212	9.2±0.1	9.3±0.1	30.0±0.5	32.1±0.4**	29.6±0.2	29.9±0.3
7 "	254	224	9.7±0.1	9.9±0.1	34.3±0.4	34.0±0.3	28.2±0.2	29.0±0.2**
10 "	44	52	11.2±0.2	10.7±0.3	38.0±0.9	38.2±0.7	29.5±1.3	28.6±0.3
3 weeks	394	364	10.3±0.1	10.6±0.1	35.4±0.3	35.8±0.3	29.1±0.2	29.3±0.2
5 "	385	353	9.3±0.1	9.5±0.1	32.5±0.3	32.5±0.3	28.5±0.2	28.7±0.2
7 "	34	44	9.2±0.2	9.0±0.2	31.2±0.8	30.4±0.8	29.2±0.3	29.7±0.4
9 "	42	52	10.9±0.3	10.7±0.3	35.1±0.7	34.3±0.8	30.7±0.4	31.6±0.5
3 months	40	49	12.2±0.2	12.4±0.2	38.8±0.6	38.3±0.7	31.5±0.5	32.9±0.5*
4 "	41	50	12.2±0.2	12.1±0.2	37.1±0.5	36.8±0.5	32.8±0.4	33.3±0.5
5 "	36	42	13.9±0.2**	13.1±0.2	40.7±0.7	39.1±0.7	34.0±0.4	33.6±0.5
6 "	17	46	12.2±0.3	12.7±0.2	38.0±1.0	40.0±0.7	33.5±0.5	32.1±0.4
7 "	..	15	.....	14.2±0.3	.....	44.2±0.9	.....	31.2±0.3
8 "	..	15	.....	14.3±0.5	.....	42.1±1.4	.....	33.9±0.6
9 "	..	15	.....	13.7±0.3	.....	40.6±1.0	.....	33.8±0.2
10 "	..	15	.....	14.0±0.4	.....	42.7±1.2	.....	32.6±0.4
11 "[c]	..	11	.....	14.3±0.4	.....	40.9±0.9	.....	34.9±0.7
12 "[d]	..	23	.....	13.2±0.2	.....	38.6±0.5	.....	34.2±0.3
2 years[c]	..	13	.....	13.1±0.2	.....	38.6±0.7	.....	34.0±0.5
2 years[d]	..	15	.....	12.5±0.2	.....	36.8±0.5	.....	34.0±0.5

[a] Castrated at 4 weeks of age.
[b] Standard error of the mean.
[c] Mid to late gestation.
[d] Near farrowing.
* Significantly ($P<0.05$) greater than corresponding value for other sex.
** $P<0.01$.

increased rate of erythropoiesis. This increased rate of erythropoiesis is sustained by supplying the proper nutritional needs, particularly iron, to the rapidly growing animals. Intramuscular injection of iron-dextran at 3 days of age in these studies has provided iron in a rapidly available and highly utilizable form (Ullrey *et al.*, 1959). The second trend toward anemia occurs later in the suckling period and is most critical at weaning—5 or 6 weeks of age. Miller *et al.* (1960) have estimated that the maintenance of optimal blood hemoglobin levels in suckling pigs to 5 weeks of age requires 150 mg. of iron totally utilized for hemoglobin biosynthesis. The data in the present study suggests that as the supply of available iron for hemoglobin biosynthesis becomes exhausted the anemia trend is accelerated. This trend is again reversed by the physiological forces which stimulate erythropoiesis and is maintained by an adequate supply of iron provided by post-weaning natural dry swine diets (Ullrey *et al.*, 1960; Matrone *et al.*, 1960; Pickett *et al.*, 1960).

Later in life there is still another period when there is a tendency toward anemia. This is observed in females in late pregnancy and appears to be a very moderate anemia similar to what Wintrobe (1956) terms a "physiological" or "pseudo" anemia developing in women from hemodilution (Lapan and Friedman, 1958) caused by a progressive increase in plasma volume during pregnancy. Friedell *et al.* (1951) and Miller *et al.* (1961) have shown a relative increase of the plasma or serum albumin-globulin ratio in sows and gilts during pregnancy which could be responsible for an increase in plasma volume similar to that observed in women.

Hemoglobin, Hematocrit and Erythrocyte. The changes in values of blood hemoglobin (Hb), hematocrit (Ht) and erythrocyte (RBC) population which occur throughout the life of swine are relatively parallel (figure 1). Values for the newborn pig are similar to those found in adult swine. By three days of age a 25% reduction in Hb, Ht and RBC has occurred. This reduction has been observed by many (Calhoun and Smith, 1958; Weide and Twiehaus, 1959; Patyra *et al.*,

TABLE 2. COMPARISONS OF BLOOD ERYTHROCYTE AND RETICULOCYTE CONCENTRATION, MEAN CORPUSCULAR VOLUME AND MEAN CORPUSCULAR HEMOGLOBIN IN MALE AND FEMALE SWINE

Age	Number of animals		Erythrocytes, 10^6/mm^3		Reticulocytes, % of RBC		MCV, μ^3		MCH, $\mu\mu$g	
	Male[a]	Female	Male	Female	Male	Female	Male	Female	Male	Female
Birth	55	52	6.22±0.14[b]	6.18±0.15	0.6±0.1	0.7±0.1	64.9±1.1	64.7±1.1	20.5±0.3	20.4±0.4
1 day	29	54	5.91±0.14	6.67±0.19*	.....	.....	64.8±1.3	64.9±1.3	19.6±0.4	19.4±0.4
2 days	54	46	5.33±0.14	5.73±0.15*	1.7±0.3	1.5±0.3	60.0±1.0	60.0±1.1	17.9±0.3	18.2±0.4
3 "	23	25	4.62±0.23	4.51±0.18	5.0±0.5	5.5±0.5	62.7±2.2	65.7±6.0	18.2±0.9	22.4±0.9**
7 "	65	60	4.91±0.13	5.15±0.14	4.6±0.7*	3.2±0.2	64.8±2.0	63.5±1.5	18.4±0.3	18.5±0.4
10 "	44	50	5.85±0.17	5.82±0.16	3.9±0.7	4.3±0.6	66.5±1.5	67.8±1.7	19.6±0.5	19.3±0.5
3 weeks	122	119	5.86±0.15	5.79±0.13	1.4±0.3	1.4±0.3	58.2±1.0	58.6±0.8	17.7±0.3	17.9±0.3
5 "	80	79	5.71±0.16	6.25±0.16	1.5±0.4	1.7±0.9	52.3±1.0	50.7±1.1	15.2±0.3	15.0±0.3
7 "	11	21	5.38±0.42	5.13±0.34	7.9±0.8	6.6±1.3	49.4±4.3	53.0±3.5	16.6±1.8	17.1±1.3
9 "	12	20	6.50±0.29	5.75±0.29	4.3±0.7	3.7±0.5	49.6±3.3	52.6±2.6	16.2±1.4	18.0±1.2
3 months	12	18	7.40±0.17**	6.53±0.22	1.3±0.3	0.9±0.2	48.3±1.7	51.9±2.1	16.6±0.9	18.8±0.9
4 "	12	19	7.09±0.16*	6.42±0.22	1.3±0.2	1.2±0.2	52.2±1.6	55.4±1.6	19.5±0.8	20.0±0.7
5 "	12	17	6.96±0.31	6.65±0.21	0.2±0.1	0.1±0.0	54.0±2.8	53.8±1.3	20.1±1.2	20.0±0.6
6 "	8	28	7.00±0.31	6.87±0.24	1.3±0.3	1.4±0.3	56.0±0.9	62.0±1.9*	19.5±1.2	19.9±0.7
7 "	..	15	.....	7.52±0.18	.....	0.3±0.0	.....	64.3±1.4	.....	20.1±0.5
8 "	..	15	.....	6.60±0.28	.....	0.2±0.0	.....	61.1±4.4	.....	21.8±0.6
9 "	..	15	.....	6.95±0.27	.....	0.4±0.1	.....	58.9±1.3	.....	19.9±0.4
10 "	..	15	.....	7.09±0.22	.....	0.3±0.1	.....	60.5±1.4	.....	19.9±0.5
11 "[c]	..	11	.....	7.61±0.24	.....	7.4±1.4	.....	56.9±1.1	.....	18.8±0.4
12 "[d]	..	24	.....	6.90±0.12	.....	6.3±0.8	.....	56.0±0.8	.....	19.2±0.3
2 years[c]	..	13	.....	6.61±0.14	.....	6.6±0.9	.....	58.0±1.1	.....	19.7±0.3
2 years[d]	..	15	.....	6.27±0.20	.....	6.3±1.2	.....	59.0±1.6	.....	20.0±0.5

[a] Castrated at 4 weeks of age.
[b] Standard error of the mean.
[c] Mid to late gestation.
[d] Near farrowing.
* Significantly ($P<0.05$) greater than corresponding value for other sex.
** $P<0.01$.

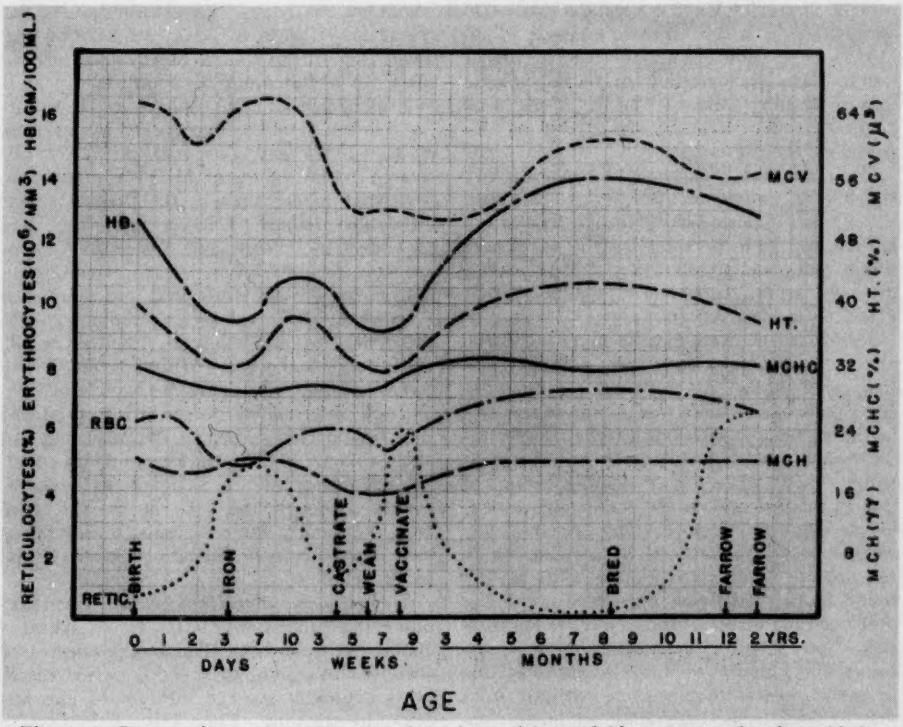

Figure 1. Changes in erythrocyte population, size and hemoglobin concentration from birth to maturity.

1956; Barber *et al.*, 1958; Kliesch and Neuhaus, 1959; Schulze, 1959; Ullrey *et al.*, 1959; Zimmerman *et al.*, 1960; Gwatkin and L'Ecuyer, 1959, 1960; Haaranen, 1960; Miller *et al.*, 1960; Gehle *et al.*, 1961) and is reversed only by the administration of some form of supplemental iron. McCance and Widdowson (1959) have shown a 30% increase in plasma volume as a result of the absorption of globulins from colostrum. Plasma volume is further increased by the rapid growth of the pig and biosynthesis of serum albumin (Miller *et al.*, 1961) and may be entirely responsible for the reduced values of RBC, Ht and Hb although Patyra *et al.* (1956) have interpreted the reduction of Hb to result from the disintegration of hemoglobin in order that metaporphyrin might be released for the rapid formation of tissue enzymes.

After a single intramuscular injection of iron-dextran at 3 days of age Hb, Ht and RBC values were increased and sustained for a period of about 4 weeks. This has been reported by Barber *et al.* (1955, 1958); Kernkamp (1957); Dale and MacKay (1958); Terpstra and Akkermans (1958); Doornenbal (1959); Maner *et al.* (1959); Rydberg *et al.* (1959); Ullrey *et al.* (1959); Zimmerman *et al.* (1959, 1960); Gwatkin and L'Ecuyer (1959); Miller *et al.* (1960) and Wahlstrom and Juhl (1960). Values of Hb and Ht observed at weaning were similar to pre-iron-administration values. RBC values were somewhat higher. After weaning, Hb, Ht and RBC values increased to essentially adult values at 5 months of age. Belcher and Harriss (1957) found similar post-weaning hematocrit changes in rats. These authors determined that red cell volume per unit weight in the rat did not change appreciably with age or growth but that plasma volume per unit weight decreased with increasing age and weight. The increase in hematocrit values was due to a percentage decrease in plasma volume during body growth and maturity. Hansard *et al.* (1951, 1953) and Hansard (1956) have shown a

percent decrease in blood volume with increasing body weight in swine. Bush *et al.* (1955) have shown a greater percent reduction in plasma volume than in red cell volume in post-weaning animals. The net result is an increase in post-weaning hematocrit as observed in the present study.

Castrated male pigs tended to have slightly higher RBC values than females as Senftleben (1919) has reported but Hb and Ht values did not appear to be influenced by sex. There was a reduction of Hb, Ht and RBC values of sows in late pregnancy. Ritchie *et al.* (1960) also observed this.

Reticulocytes. Reticulocyte numbers in the pig at birth in this study were generally less than one percent of the total erythrocytes. By 3 days of age there was a definite increase in the number of circulating reticulocytes indicating an accelerated hematopoiesis (Wintrobe, 1956). Parenteral administration of iron at this age maintained rather high reticulocyte numbers for an ensuing period of one week to 10 days followed by a reduction in reticulocyte numbers as Ullrey *et al.* (1959) found in pigs receiving parenteral iron. Another marked increase in reticulocyte numbers was observed after weaning. This was sustained for a period of 2 weeks probably due to much greater dietary iron received from dry natural feeds than that obtained from sow's milk. Reticulocyte numbers were generally less than one percent of the total erythrocytes in older animals with the exception of females in middle or late gestation. These three periods of higher concentration of reticulocytes follow the corresponding three tendencies toward anemia pointed out in the earlier discussion. Values obtained in this study are not dissimilar to the findings of Fraser (1938) and Wirth *et al.* (1939). There appeared to be no sex influence on reticulocyte numbers in swine. There was a considerable degree of variation in reticulocyte numbers at many of the ages measured.

Mean Corpuscular Volume. Average values of mean corpuscular volume (MCV) of pigs at birth were 65 μ^3. This is similar to values observed for Yorkshires and crossbreds by Waddill (1960) and for Durocs but not Hampshires by Swenson *et al.* (1958). The MCV values diminished to 60 μ^3 during the first 2 days of life possibly due to a greater serum osmotic force from increased concentration of serum proteins obtained from colostrum (Miller *et al.*, 1961). Concurrent with the initial increase in reticulocyte numbers beginning at 3 days of age there was an increase in MCV to 67 μ^3 at 10 days of age. Thereafter there was a steady decrease in MCV to a minimum of about 50 μ^3 at 3 months of age. Similar changes in MCV during this age period were observed by Swenson *et al.* (1958) and Ullrey *et al.* (1959) although actual values of MCV reported were somewhat higher than in the present study. Calculated values of MCV from the data presented by Weide and Twiehaus (1959) are considerably lower. It is interesting to note in the present study that at 3 months of age, when MCV values are minimum, erythrocyte, serum γ-globulin (Miller *et al.*, 1961) and leukocyte (Miller *et al.*, 1959) concentrations were high. Perhaps some significant interrelated forces have produced this relationship. Average MCV values for older animals in this study were 55 to 65 μ^3. Sex did not appear to influence MCV significantly although the cells of females were more frequently larger. Similar observations have been made in humans (Andersen and Mugrage, 1936).

Mean Corpuscular Hemoglobin. Mean corpuscular hemoglobin (MCH) values averaged 20 $\mu\mu$g in the newborn. These values decreased steadily throughout the nursing period reaching a minimum average value of 15 $\mu\mu$g just prior to weaning. This 25% reduction in MCH was largely due to a relatively similar magnitude of reduction in MCV during this period. Swenson *et al.* (1958) found a similar degree of reduction of MCH and MCV for pigs from birth to weaning. After the pigs were weaned and began to consume dry diets MCH values increased, reaching adult values at 4 months of age. Adult values of MCH were similar to those of the newborn (20 $\mu\mu$g). Values reported by Wintrobe (1956) were not dissimilar.

Mean Corpuscular Hemoglobin Concentration. Average mean corpuscular hemoglobin concentration (MCHC) values of newborn and adult swine were over 30%. The only period of life during which MCHC values were consistently below this level was the nursing period with lowest values obtained at weaning. Wintrobe (1956) observed a similar phenomenon in humans. Post-weaning MCHC values increased to maturity. Sows and gilts had average MCHC values of 34% which is the same as for human adults (Wintrobe, 1956). Sex did not appear to exert an influence on MCHC values.

It may be noted from an inspection of fig-

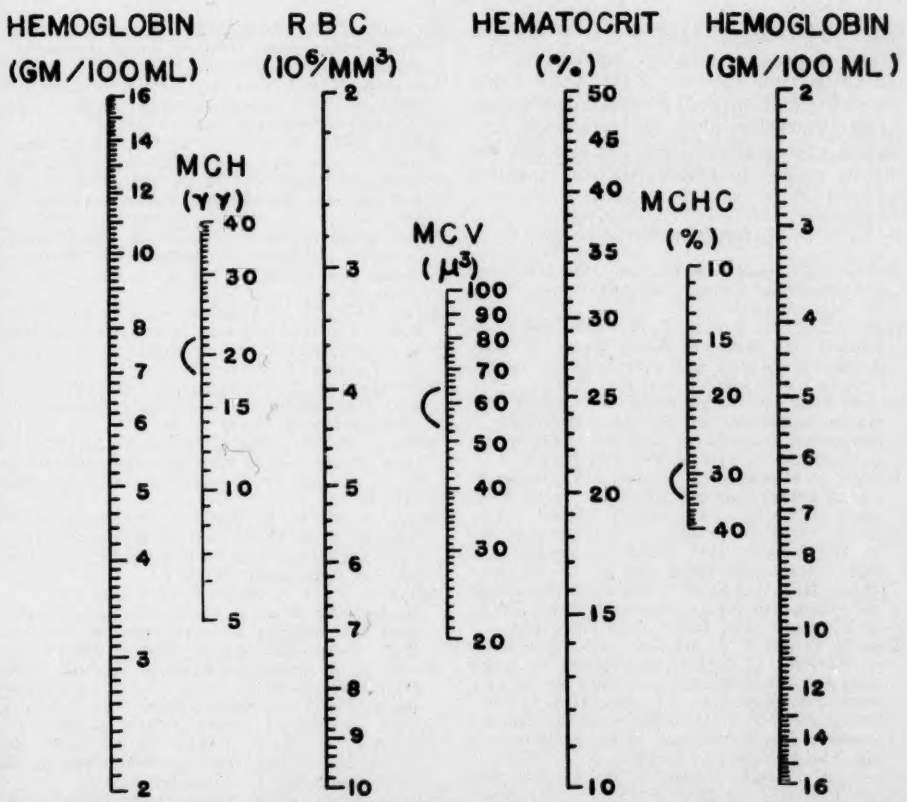

Figure 2. Nomographic alignment chart for reading of corpuscular constants. (Modification of chart prepared by Robert E. Mason in Clinical Hematology by Wintrobe, courtesy of Lea & Febiger.) For mean corpusular hemoglobin (M.C.H.) join the value for hemoglobin in the scale on the left and red cell count (R.B.C.) with a straight edge and make a reading where this line intersects the M.C.H. scale. For mean corpuscular volume (M.C.V.) similarly join the values for R.B.C. and hematocrit and read on the M.C.V. scale. Likewise, for mean corpuscular hemoglobin concentration (M.C.H.C.) join the values for hematocrit and the hemoglobin scale on the right and read on the M.C.H.C. scale. Mean values (± one standard deviation) of M.C.H., M.C.V. and M.C.H.C. for mature swine are indicated by brackets.

ure 1 that values of RBC, Hb and Ht traverse rather parallel paths from birth to maturity, for example all values are low at 3 days of age and just prior to iron administration. While values of RBC, Hb and Ht vary greatly within the same animals at different ages, values of corpuscular constants, particularly MCHC, vary to a much lesser degree due to these parallel changes in RBC, Hb and Ht. Figure 2 has been modified from Wintrobe (1956) to serve as a nomographic alignment chart for rapidly reading corpuscular constants for a range of RBC, Hb and Ht values of swine blood.

Summary

Studies have been conducted and data presented from over 16,000 determinations related to erythrocyte population, size and hemoglobin concentration in swine at frequent age intervals from birth to maturity. Rapid decreases in erythrocyte population, size and hemoglobin concentration occurred shortly after birth probably due to hemodilution following colostrum consumption. All values were low at weaning. Post-weaning values rose to adult values in most measures at 5 months of age. A slight anemia existed in sows and gilts in late gestation. A reticulocyte re-

sponse accompanied each period of anemia. Values of mean corpuscular hemoglobin concentration were low only in the suckling pig. There was no consistent influence of sex upon erythrocyte values although erythrocyte population was usually slightly less and cell size slightly greater in females than in castrated males.

Literature Cited

Andersen, M. L. and E. R. Mugrage. 1936. Red blood cell values for normal men and women. Arch. Int. Med. 58:136.

Barber, R. W., R. Braude, P. M. Clarke and K. G. Mitchell. 1958. Studies on anemia in pigs. III. Comparison of one, two and three injections of iron for pigs reared indoors. Vet. Rec. 70:13.

Barber, R. W., R. Braude and K. G. Mitchell. 1955. Studies on anemia in pigs. II. Comparison of haemoglobin levels in blood of pigs reared indoors and outdoors on pasture. Vet. Rec. 67:543.

Belcher, E. H. and E. B. Harriss. 1957. Studies of plasma volume, red cell volume and total blood volume in young growing rats. J. Physiol. 139:64.

Bush, J. A., W. N. Jensen, G. E. Cartwright and M. M. Wintrobe. 1955. Blood volume studies in normal and anemic swine. Am. J. Physiol. 181:9.

Calhoun, M. L. and E. M. Smith. 1958. Hematology and hemopoietic organs. Diseases of Swine. Ed. by H. W. Dunne, Iowa State College Press, Ames.

Dale, D. G. and V. C. MacKay. 1958. Observations on the effect of injected iron-dextran on weight gains and hemoglobin levels of baby pigs on early weaning schedule. Can. J. Comp. Med. 22:371.

Doornenbal, H. 1959. The effect of certain oral and injectable iron preparations on the blood of baby pigs. Can. J. Animal Sci. 39:193.

Fraser, A. C. 1938. A study of the blood of pigs. Vet. J. 94:3.

Friedell, R. W., J. F. Foster, D. V. Catron and M. R. Dieckmann. 1951. Electrophoretic studies on swine. II. The composition of plasma during gestation and lactation. Iowa State College J. Sci. 25:521.

Gehle, M. H., L. C. Payne, E. R. Peo, Jr. and C. L. Marsh. 1961. Interrelationship of growth rate, hemoglobin dilution, packed cell volume and incidence of anemia in suckling pigs. J. Am. Vet. Med. Assn. 138:81.

Gwatkin, R. and C. L'Ecuyer. 1959. Test of some injectable iron products in pigs. Can. J. Comp. Med. 23:29.

Gwatkin, R. and C. L'Ecuyer. 1960. Rhinitis of Swine. IV. Hematology of infected and normal pigs. Can. J. Comp. Med. 24:6.

Haaranen, S. 1960. Some blood components of growing pigs. Nord. Veterinarmed. 12:239.

Hansard, S. L. 1956. Residual organ blood volume of cattle, sheep and swine. Proc. Soc. Exp. Biol. Med. 91:31.

Hansard, S. L., W. O. Butler, C. L. Comar and C. S. Hobbs. 1953. Blood volume of farm animals. J. Animal Sci. 12:402.

Hansard, S. L., H. E. Sauberlich and C. L. Comar. 1951. Blood volume of swine. Proc. Soc. Exp. Biol. Med. 78:544.

Jacobsen, L. O., E. Goldwasser, W. Fried and L. F. Plzak. 1957. Studies on erythropoiesis. VII. The role of the kidney in the production of erythropoietin. Trans. Assoc. Am. Phys. 70:305.

Jacobsen, L. O., L. Plzak, W. Fried and E. Goldwasser. 1956. Plasma factor(s) influencing red cell production. Nature 177:1240.

Kernkamp, H. C. L. 1957. A parenteral hematinic for the control of iron-deficiency anemia in baby pigs. N. Am. Vet. 38:6.

Kliesch, J. and V. Neuhaus. 1959. Untersuchungen über die Beziehungen zwischen Erythrozytenzal und Hamoglobingehalt des Blutes von Ferkeln und ihrer späterne Entwicklung. Zücktungskunde 30: 353.

Lapan, B. and M. M. Friedman. 1958. Blood studies in normal pregnancy and the newborn: The effect of iron and calcium administration. Am. J. Obs. & Gynec. 76:96.

Maner, J. H., W. G. Pond and R. S. Lowrey. 1959. Effect of method and level of iron administration on growth, hemoglobin and hematocrit of suckling pigs. J. Animal Sci. 18:1373.

Matrone, G,. E. L. Thomason, Jr. and C. R. Bunn. 1960. Requirement and utilization of iron by the baby pig. J. Nutr. 72:459.

McCance, R. A. and E. M. Widdowson. 1959. The effect of colostrum on the composition and volume of the plasma of newborn piglets. J. Physiol. 145:547.

Miller, E. R., D. E. Ullrey, I. Ackerman, D. A. Schmidt, J. A. Hoefer and R. W. Luecke. 1961. Swine hematology from birth to maturity. I. Serum proteins. J. Animal Sci. 20:31.

Miller, E. R., D. E. Ullrey, R. W. Luecke and J. A. Hoefer. 1960. The use of injectable iron preparations in preventing baby pig anemia. 5th Ann. Mich. Swine Day Report, Mimeo. AH–53.

Patyra, S., H. Kraczkowski and W. Zalewski. 1956. Wplyw warunkow wychown i wieku na niektore skladniki krwi obwodowej u prosiat. Ann. U Mariae Curie—Sklodowska Lublin—Polonia 11:205.

Pickett, R. A., M. P. Plumlee, W. H. Smith and W. M. Beeson. 1960. Oral iron requirement of the early-weaned pig. J. Animal Sci. 19:1284.

Ritchie, H. D., E. R. Miller, D. E. Ullrey, J. A. Hoefer and R. W. Luecke. 1960. Supplementation of the swine gestation diet with pyridoxine. J. Nutr. 70:491.

Rydberg, M. E., H. L. Self, T. Kowalczyk and R. H. Grummer. 1959. The effectiveness of three different methods of iron administration to young pigs. J. Animal Sci. 18:410.

Schulze, W. 1959. Nabelblutuntersuchungen bei neugeborenen Ferkeln mit Berucksichtigung der Narkose bei der Sau. XVI. Congreso Mundial De Veterinaria 1:255.

Senftleben, O. 1919. Das Blutbild des gesunden Schweines. Monatsch. fur Prakt. Tierheilk. 30:289.

Swensen, M. J., G. K. L. Underbjerg, D. D. Goetsch and C. E. Aubel. 1958. Blood values and growth of newborn pigs following subcutaneous implantation of bacitracin pellets. Am. J. Vet. Res. 19:554.

Terpstra, J. I. and J. P. W. M. Akkermans. 1958. Anemie bij biggen. Overdruk Tijdsch. Diergeneeskunde. 83:639.

Ullrey, D. E., E. R. Miller, O. A. Thompson, I. M. Ackermann, D. A. Schmidt, J. A. Hoefer and R. W. Luecke. 1960. The requirement of the baby pig for orally administered iron. J. Nutr. 70:187.

Ullrey, D. E., E. R. Miller, D. R. West, D. A. Schmidt, R. W. Seerley, J. A. Hoefer and R. W. Luecke. 1959. Oral and parenteral administration of iron in the prevention and treatment of baby pig anemia. J. Animal Sci. 18:256.

Waddill, D. G. 1960. Hematology of the fetal and newborn pig. I. Cellular populations and serum protein concentrations. Ph.D. Thesis. Michigan State University, East Lansing, Michigan.

Wahlstrom, R. C. and E. W. Juhl. 1960. A comparison of different methods of iron administration on rate of gain and hemoglobin level of the baby pig. J. Animal Sci. 19:183.

Weide, K. D. and M. J. Twiehaus. 1959. Hematological studies of normal, ascarid-infected and hog cholera-vaccinated swine. Am. J. Vet. Res. 20:562.

Wintrobe, M. M. 1956. Clinical Hematology. Lea & Febiger, Philadelphia.

Wirth, D., F. Rossmann and G. Benndorf. 1939. Studien zur artspezifischen Reaktion der hamatopoetschen Organsysteme. V. Schwein. Fol. Haem. 61:1.

Zimmerman, D. R., V. C. Speer, V. W. Hays and D. V. Catron. 1959. Injectable iron-dextran and several oral iron treatments for the prevention of iron-deficiency anemia of baby pigs. J. Animal Sci. 18:1409.

Zimmerman, D. R., V. C. Speer, V. W. Hays and D. V. Catron. 1960. A comparison of intramuscular and intraperitoneal injection of iron-dextran. J. Animal Sci. 19:484.

LAMB PRODUCTION AS AFFECTED BY FORAGE MIXTURE AND GRAZING MANAGEMENT OF PERENNIAL PASTURES [1]

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CLIMATIC and soil variations necessitate pasture studies with a wide variety of plant species. Fuelleman *et al.* (1944) demonstrated that bromegrass (*Bromus inermis*) or orchardgrass (*Dactylis glomerata*) alone yielded 50% as much in sheep gains as legume-grass mixtures including them. Harrison *et al.* (1947) reported sheep gains and days of grazing twice as great during a 3-year period where alfalfa (*Medicago sativa*) was present in the mixture as compared with grasses alone or red clover (*Trifoleum pratense*) grass mixtures.

Washko and Pennington (1956) stated that protein and dry matter yield per acre were higher for grasses plus nitrogen while the protein was 0.5% and 2% higher in the first and second cuts, respectively, of the legume-grass mixtures over the grasses alone.

Harrison *et al.* (1941) reported little difference in acre gains between continuous grazing and rotational grazing of alfalfa-bromegrass for ewes and lambs. Lambourne (1956) concluded that rotational grazing increases the animal output per acre by an increase in carrying capacity and not by increase in the production per animal.

The objectives of this study were to determine the effect on lamb production and legume stand of: (1) number of rotational paddocks used; (2) alfalfa-bromegrass pasture mixture as compared to fertilized bromegrass; and (3) self-feeding grain to grazing lambs.

Experimental Procedures

Six acres of rather level uniform land were divided into 12 half-acre paddocks. A uniform fertilizer application of 400 lb. per acre of 5–20–20 was made on the entire area prior to seeding in the fall of 1958. A maintenance application of 400 lb. per acre of 0–12–36 was applied in October, 1959. Nitrogen applications were made on the bromegrass pastures following each grazing period, totaling 110 lb. nitrogen per acre in 1959 and 140 lb. in 1960.

The following treatments, replicated three times, were used: (1) alfalfa-bromegrass paddock divided into three lots for rotational grazing, hereafter referred to as alfalfa-bromegrass 3X; (2) alfalfa-bromegrass paddock divided into two lots for rotational grazing, hereafter referred to as alfalfa-bromegrass 2X; (3) nitrogen-fertilized bromegrass pasture divided into three lots for rotational grazing, hereafter referred to as bromegrass 3X; and (4) alfalfa-bromegrass pasture 3X plus grain self-fed. The grain consisted of a mixture of 95% rolled shelled corn and 5% soybean oil meal. In addition, the mixture contained 10 mg. oxytetracycline per pound of ration.

Early-weaned lambs, 11 to 13 weeks of age, were used as the test animals during both years. Each lamb was drenched with ½ oz. phenothiazine before being placed on test and nine parts of mineralized salt and one part phenothiazine was self-fed in covered salt boxes to all lots.

In 1959 the grazing season commenced on May 19. On the pastures where 3X rotational grazing was followed, one-third of the area was cut for hay on June 8th. Where 2X rotational grazing was followed, one-half of the area was cut for hay on the same date. The various pastures were credited with addi-

[1] Paper No. 4593, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul, Minnesota. Research in cooperation with Departments of Animal Husbandry, Agronomy and Plant Genetics, University of Minnesota, and the Crops Research Division, Agricultural Research Service, United States Department of Agriculture.

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tional lamb gains by assuming the hay contained 50% total digestible nutrients and each 1¼ lb. TDN produced as hay was equivalent to an additional lamb day.

In 1960 (the second year of grazing), grazing commenced on May 10. At that date the legume and grasses were about 4–6 in. high due to a rather cold, late spring. This earlier grazing date eliminated the necessity of removing the excess forage as hay.

The daily gains are based on the gains made by the "tester" lambs. These lambs remained on the pasture for the entire grazing season. However, in order to regulate forage utilization, additional lambs were added to the pasture to consume the surplus forage and removed when forage was less available. These lambs were considered as "grazers". The lamb days per acre are a combination of the lamb days of the "tester" animals and the lamb days of the "grazer" animals.

Plant counts were taken in the fall of 1959 and again in 1960 to determine the effect of pasture management on plant stand.

Significance of treatment differences for all factors studied was determined by Duncan's (1955) multiple range test.

Results and Discussion

The use of lambs as grazing animals was satisfactory from the standpoint of adjusting the grazing pressure as well as utilizing the majority of forage by grazing. No difficulty was encountered with scours or bloat on young succulent pasture. Results of the two experiments as well as the average for both experiments are presented in table 1.

Carrying Capacity. An appreciably greater number of lamb grazing days was obtained with alfalfa-bromegrass 3X than alfalfa-bromegrass 2X grazing ($P<0.05$). This in-

TABLE 1. LAMB PRODUCTION AS AFFECTED BY PLANT SPECIES AND MANAGEMENT OF PERENNIAL PASTURES

Treatments[a]	Alfalfa-brome 3X 1	Alfalfa-brome 2X 2	Brome 3X 3	Alfalfa-brome and grain 3X 4
	Experiment 1—1959 (average 3 replications)			
Av. no. lambs/acre	23.4	23.2	20.8	29.4
Lamb days/acre[b]	2203.0	1949.0	1957.0	2762.0[e]
Av. daily gain, lb.	0.29	0.29	0.21	0.41[e]
Lamb/acre, lb.	632.0	559.0	417.0	1132.0
Grain/lamb daily, lb.	.....	.....	.....	1.46
Grain/lb. gain, lb.	.....	.....	.....	3.56
Av. final wt., lb.	82.9	83.1	77.4	92.5
	Experiment 2—1960 (average 3 replications)			
Av. no. lambs/acre	18.6	14.6	18.3	30.5
Lamb days/acre	1712.0	1344.0	1680.0	2810.0[e]
Av. daily gain, lb.	0.30	0.32	0.27	0.49[e]
Lamb/acre, lb.	515.0	429.0	454.0	1376.0
Grain/lamb daily, lb.	.....	.....	.....	1.64
Grain/lb. gain, lb.	.....	.....	.....	3.36
Av. final wt., lb.	78.5	79.7	77.3	96.4
	Average Experiments 1 and 2			
Av. no. lambs/acre	21.0	18.9	19.6	29.9
Lamb days/acre	1957.0[e]	1646.0	1818.0	2786.0[e]
Av. daily gain, lb.	0.29	0.30	0.24	0.45[e]
Lamb/acre, lb.	574.0[d]	494.0	435.0	1254.0[e]
Grain/lamb daily, lb.	.....	.....	.....	1.55
Grain/lb. gain, lb.	.....	.....	.....	3.46

[a] Treatments were:
(1) Alfalfa-bromegrass pasture divided into 3 grazing areas and the lambs were rotated between the 3 areas referred to as alf-brome 3X;
(2) Alfalfa-bromegrass pasture with the lambs rotated between 2 areas, alf-brome 2X;
(3) Bromegrass pasture 3X rotation; and
(4) Alfalfa-bromegrass 3X rotation with grain self-fed.
[b] Includes grazing days conversion from hay cut in 1959.
[c] Statistically different from Treatments 1, 2 and 3 ($P<0.01$).
[d] Statistically different from Treatments 2 and 3 ($P<0.05$).
[e] Statistically different from Treatment 2 ($P<0.05$).

crease amounted to about 12% in 1959 and 22% in 1960. This increased carrying capacity largely reflects the longer grazing season that was made possible by 3X rotational grazing as well as an increase in the number of lambs pastured per acre. Under the 3X grazing system the lambs were turned onto a fresh grazing area every 12 to 18 days. With the 2X rotational grazing system the lambs were moved onto a fresh grazing area every 24 to 26 days. Regardless of the number of rotational areas, the lambs grazed over the area uniformly.

Alfalfa-bromegrass 3X had about 12% greater carrying capacity than bromegrass 3X in 1959 but only 2% greater carrying capacity in 1960. These differences were non-significant. In the first year of grazing the bromegrass stand was not as vigorous as it was in 1960. During both years alfalfa-bromegrass 3X provided for a longer grazing period due to the tendency of bromegrass to cease growing in late summer. However, in 1960 (second year of grazing) the bromegrass provided forage for more lambs during the early phase of the grazing season than the alfalfa-bromegrass pastures.

In 1959 alfalfa-bromegrass 2X and nitrogen-fertilized bromegrass 3X provided for about the same number of lamb days per acre. In 1960 the fertilized bromegrass provided for about 20% more lamb days than alfalfa-bromegrass 2X rotation. Differences in carrying capacity between alfalfa-bromegrass 2X and bromegrass 3X for both years were non-significant.

Self-feeding grain increased the carrying capacity of the pastures appreciably ($P < 0.01$). In 1959, feeding grain to lambs pasturing alfalfa-brome 3X resulted in approximately 25% greater carrying capacity per acre than similar pastures without grain. In 1960, 64% more lamb days were obtained when grain was self-fed than comparable pastures grazed without grain feeding. During both years it was apparent that the lambs stayed near the self-feeders a good share of the time and grazed less than lambs grazing similar pastures that were not receiving grain.

One of the problems encountered in this study was the failure of the bromegrass pastures to maintain production in periods of drought. Similarly, alfalfa-bromegrass pastures also tended to recover so slowly from grazing that it necessitated curtailing the grazing program in mid-August. At this time the lambs were removed from the pasture. After a period of 2 to 3 weeks of no grazing these pastures had considerable regrowth of forage.

The management of the grazing animals, such as the frequency of rotating the grazing areas, grain feeding, the number of years the pasture had been established, as well as the forage species (alfalfa or bromegrass), appeared to have a bearing on the carrying capacity of the pasture areas. The average carrying capacities during the 2 years were: alfalfa-brome 3X, 1957 lamb days; fertilized bromegrass 3X, 1818 lamb days; alfalfa-bromegrass 2X, 1646 lamb days; and alfalfa-bromegrass 3X plus grain feeding, 2786 lamb days.

Average Daily Gain. Differences in rate of gain of the lambs on different frequencies of pasture rotation or forage mixtures were non-significant. The lambs grazing bromegrass actually gained slightly less over the entire grazing season each year.

The lambs self-fed grain on pasture consumed about 1½ lb. grain per lamb daily and gained significantly faster both years as compared to lambs that did not receive grain. This increase in average daily gain amounted to about 42% in 1959 and about 62% in 1960.

In general, the average gains made by the lambs that received no supplemental grain feeding were considered unsatisfactory. Jordan *et al.* (1959) reported that early-weaned creep-fed lambs gain as rapidly as creep-fed lambs that are allowed to suckle their dams. For example, in four separate trials early-weaned creep-fed lambs gained 0.40 to 0.65 lb. per lamb daily regardless of whether they were grain fed in drylot or on pasture.

Average non-weaned lambs grazing legume pasture with no supplemental grain feeding will gain about 0.40 lb. per lamb daily. While a comparison between the lamb gains made in this pasture study with average lamb gains made by non-weaned lambs is not entirely valid, it does illustrate that pasture as the only source of nutrients for early-weaned lambs may not be consumed in sufficient quantities to enable one to market lambs off pasture in 80 to 90 days. During both years lambs grazing pasture with no grain feeding weighed about 80–85 lb. when removed from pasture in late August and required an additional 40 to 50 days of grain feeding before marketing. The self-feeding of grain during the grazing season resulted in the lambs weighing about

92–95 lb. with sufficient finish to grade choice and prime.

Lamb Production per Acre. The average lamb production per acre for both years was more than doubled by feeding grain to the lambs on pasture. This significantly greater lamb production per acre is a reflection, not only of the greater carrying capacity, but of faster daily gains. Bromegrass 3X pasture, though heavily fertilized with nitrogen, produced 34% less lamb gain per acre than alfalfa-bromegrass 3X. In 1960, the second year of grazing, about 12% fewer pounds of lamb were produced on bromegrass 3X than on alfalfa-bromegrass 3X. Lamb production on alfalfa-brome 2X was about 25% greater than on bromegrass 3X during the first year of grazing but about 6% less during the second season of grazing. Alfalfa-bromegrass 3X produced significantly more lamb per acre than either alfalfa-bromegrass 2X or bromegrass 3X for the 2-year period.

Feeding grain on pasture materially increased the average daily gain, improved the carcass grade and increased the carrying capacity of the pasture. When accompanied by proper stocking, grain feeding alleviated the problem of inadequate forage after mid-August and light underfinished lambs at the time the pasture season ended. It appears that these problems could be alleviated by: (1) the feeding of grain to lambs during the entire grazing season such as was followed in this study or (2) commencing the grain feeding when the pasture productivity starts to decline and the forage consumption by the lambs exceeds the forage production. This normally would be about mid-July in this area.

Forage production on the alfalfa-bromegrass pastures during late August and early September cannot safely be utilized if one is concerned with the maintenance of a vigorous stand the following year. Conversely, bromegrass pastures can be grazed during the month of September without as much damage to the stand. In this connection a pilot study was conducted in the fall of 1960. Twelve 80-lb. lambs were grazed per acre on bromegrass pasture. The average daily gain was only 0.20 lb. per lamb. This additional production was not sufficient to equal the greater lamb production produced on alfalfa-bromegrass 3X or to compensate for the cost of supplying the additional nitrogen fertilizer.

Plant Count. Data pertaining to the plant count are presented in table 2. A similar reduction in plant count occurred in all pastures from 1959 to 1960. There appeared to be no difference in the stands of alfalfa due to treatments at the end of two years of grazing as all treatments average about three and one-half legume plants per square foot. However winter killing may have been more severe on the 2X treatment where grazing was more severe at times. Vigor of plants is not reflected by plant count.

TABLE 2. PLANT COUNTS PER SQUARE FOOT[a]

	Legume-grass (3X)		Grasses+nitrogen (3X)		Legume-grass (2X)		Legume-grass-grain (3X)	
Plant species	Fall 1959	Fall 1960	Fall 1959	Fall 1960	Fall 1959	Fall 1960	Fall 1959	Fall 1960
Alfalfa	6.2	3.4	...	...	5.4	3.4	5.8	3.5
Bromegrass	5.1	3.0	5.3	3.6	4.9	3.2	5.2	3.9
Orchardgrass	...	...	0.4	1.6	...	...	...	...
Weeds	0.6	0.8	1.9	2.3	1.2	2.1	0.5	0.3

[a] Orchardgrass included in mixture was all winterkilled in the winter of 1958–1959 (seeding year). Small amount of orchardgrass in the bromegrass treatment is accounted for by the reseeding of bromegrass and orchardgrass on one-half of two separate grass pastures in the spring of 1959.

Encroachment of weeds was greatest on the all-grass pastures, followed closely by the alfalfa-bromegrass 2X. This suggests that the legume and grass plants under 2X grazing were less vigorous allowing weeds to come into the stands.

Summary

Early-weaned lambs were: (1) pastured on alfalfa-bromegrass pasture and rotationally grazed over either two or three paddocks; (2) pastured on fertilized bromegrass and rotationally grazed over three paddocks; or (3) self-fed grain and grazed over three alfalfa-bromegrass paddocks. Each treatment was replicated three times per year and the experiment was conducted over a 2-year period.

Grain feeding significantly ($P<0.01$) increased average daily gain, carrying capacity and lamb production per acre over the other three treatments. Alfalfa-bromegrass rotationally grazed over three paddocks resulted in significantly ($P<0.05$) greater lamb production per acre than bromegrass 3X or alfalfa-bromegrass 2X. Daily gain was not significantly affected by plant species or number of rotational paddocks. Bromegrass pasture produced more forage during the second than the first year.

Literature Cited

Duncan, D. B. 1955. Multiple range and F tests. Biometrics 11:1.

Fuelleman, R. F., W. L. Burlison and W. G. Kammlade. 1944. A comparison of bromegrass and orchardgrass pastures. J. Am. Soc. Agron. 36:849.

Harrison, C. M., H. M. Brown and H. C. Rather. 1947. The production of forage crop mixtures under different systems of management, the consequent effect on corn yields, and the re-establishment of alfalfa. J. Am. Soc. Agron. 39:214.

Harrison, C. M., C. L. Cole and H. C. Rather. 1941. Continuous and rotational grazing of alfalfa-bromegrass pastured with ewes and lambs. Soil Sci. Soc. Am. Proc. 6:303.

Jordan, R. M., H. E. Hanke and D. Reimer. 1959. The early weaning of lambs. Feedstuffs. 31:86.

Lambourne, L. J. 1956. A comparison between rotational grazing and set stocking for fat-lamb production. New Zealand J. Sci. and Tech. 37:555.

Washko, J. B. and R. P. Pennington. 1956. Forage and protein production of nitrogen-fertilized grasses compared with grass-legume associations. Penn. Agr. Exp. Sta. Bul. 611.

ERRATA

Lauprecht, Edwin. 1961. Production of a population with equal frequency of genes from three parental sources. J. Animal Sci. 20:426–428.

The last line of table 2, page 427, under P_0, P_1, and P_2 should be:

	P_0	P_1	P_2
C_n	$\frac{1}{3}+\frac{2}{3}(-\frac{1}{2})^{n+1}$	$\frac{1}{3}+\frac{2}{3}(-\frac{1}{2})^{n+1}$	$\frac{1}{3}+\frac{2}{3}(-\frac{1}{2})^{n}$

Enfield, Frank D., and J. A. Whatley, Jr. 1961. Heritability of carcass length, carcass backfat thickness and loin lean area in swine. J. Animal Sci. 20:631.

In table 1, page 632, the definition of k_2 and k_3 should be as follows:

$$k_2=\frac{1}{s\text{-}f}\left[\sum_i\sum_j\frac{1}{n_{ij}}\sum_k n^2_{ijk}-\sum_i\frac{1}{n_i}\sum_j\sum_k n^2_{ijk}\right]$$

$$k_3=\frac{1}{s\text{-}f}\left[T-\sum_i\frac{1}{n_i}\sum_j n^2_{ij}\right]$$

The results in the paper are correct as given since all results are based on the coefficients above rather than as they originally appeared.

ABSTRACTS OF PAPERS FOR PRESENTATION AT THE 53RD. ANNUAL NATIONAL MEETING OF THE AMERICAN SOCIETY OF ANIMAL PRODUCTION

The meeting will be held November 24 and 25 in the Hotel Sherman, Chicago. The abstracts include program papers for the research sections and papers to be "read by title". The author presenting paper is indicated by an asterisk. Publication deadlines do not allow thorough proofreading of these abstracts by the Editor. Where a number only is shown, the abstract either was not submitted, or was withdrawn or failed to qualify for publication.

1. PIGMENT IN RELATION TO BOVINE CANCER EYE SUSCEPTIBILITY. David E. Anderson*, and Dale W. Vogt, *The University of Texas M.D. Anderson Hospital and Tumor Institute, Houston.*

An investigation was conducted to provide insight into the factor(s) relevant to susceptibility or resistance to cancer eye. Direct examinations of eyes were made on 1591 animals representing 23 breeds and breed crosses in 15 herds located in various areas of the United States and Canada. Each herd was represented by at least two breeds or crosses (breed groups). Analyses were conducted on a pooled intra-herd and -age basis considering lesions only in the bulbar conjunctiva. Lesion frequencies differed significantly among breed groups, and ranged from 0% to 52.8%. These differences were found to be associated with pigment at the corneoscleral junction of the eyeball, a frequent site of lesion development. Lesions were observed only in breed groups having low average pigment scores, that is, having no pigment or pigment in only a small portion of the corneoscleral junction. No lesions were observed in breed groups having extensive pigment. A correlation analysis confirmed the significance of these findings and provided additional evidence indicating breed differences in susceptibility to be largely the result of differences in corneoscleral pigment. Similarly, an intra-breed analysis revealed high lesion frequency to be significantly associated with low average pigment, indicating individual differences in susceptibility to be likewise influenced by individual differences in pigment.

2. ARTIFICIAL INSEMINATION AND POPULATION STRUCTURE. G. E. Bradford*, *University of California, Davis.*

Calculations of genetic gains expected with different selection intensities commonly assume a large closed herd with all males born available for selection, an assumption which is not valid when entire breeds or classes of livestock are considered. Castration of males in commercial herds reduces selection intensity, consequently affecting the relative increase in rate of genetic improvement possible from the use of artificial insemination. For example, male selection intensity in beef cattle and sheep, with natural service, could approach 0.025 if all males are available for selection. More probable values, with existing population structure, are 0.5 to 0.8. Assuming selection intensity for females is 0.5, these would yield mean selection differentials of 1.58, 0.80 and 0.58 standard deviations respectively. Increasing the number of females bred by each male by a factor of 100, through the use of A.I., would permit corresponding selection differentials of 2.40, 1.85 and 1.77, or ratios of potential progress with A.I. to that with natural service of 1.52, 2.30 and 3.05 respectively. Less intense selection of females than assumed here would further increase the relative advantage of A.I. Stratification of the population, with the best males used in sire-producing herds and the remainder of those selected used in commercial herds would: (1) increase genetic improvement in the population as a whole, (2) decrease the relative advantage of A.I., (3) create a difference in genetic merit between sire-producing and commercial herds, the difference being equal to $\frac{2^n-1}{2^n}h^2y$, where y=difference in selection differential between the two groups of sires, and n=number of generations of differential selection.

3. ESTIMATION OF GENETIC TRENDS IN BEEF CATTLE. J. S. Brinks*, R. T. Clark and F. J. Rice, *Animal Husbandry Research Division, ARS, U.S.D.A., Denver, Colorado and Miles City, Montana.*

Data on 2027 Line 1 Hereford calves, collected from 1934 through 1959 at the United States Range Livestock Experiment Station, Miles City, Montana, were used to estimate genetic changes in birth weight, gain from birth to weaning, and weaning weight. A generation number was obtained for each calf using the formula $Go=\frac{Gs+Gd+2}{2}$ where Go=generation of offspring, Gs=generation of sire, and Gd=generation of dam. All foundation animals were considered generation zero. The data were analyzed by least squares procedures for year and generation effects after adjustments for sex, age of calf, and age of dam. Generations were grouped by one half generations from 1 to 6. Constants obtained for year effects showed a strong upward trend with increasing year number, whereas constants for generation effects were relatively constant after generation 2 for all three traits. After adjusting for inbreeding of calf and inbreeding of dam, generation effects showed a general trend upward with increasing generation number. Data on selection differentials by years and generation-year groupings are presented.

4. FAMILY STRUCTURE IN THE HAMPSHIRE BREED OF SHEEP. R. C. Carter*, *Virginia Agricultural Experiment Station, Blacksburg.*

Random samples of 200 male and 200 female lambs born in each of the years 1945 and 1955 were drawn from the American Hampshire Flock Book. Random two line pedigrees were extended from the sire and dam to the imported foundation animals. Only one individual in each line per genera-

tion back of the sire and dam were included in the pedigree, the choice of male or female parent at each generation being random. Average base date (birth date of imported foundation animals) was 1918 and 1923 respectively for the 1945 and 1955 samples. Increase in inbreeding, relative to the base date was estimated at 3.0±0.6% in 1945 and 4.3± 0.7% in 1955, averaging between 0.4 and 0.5% per generation. Average relationship between random pairs of animals in the breed was 1.7±0.6% in 1945 and 1.4±0.6% in 1955. Generation interval averaged 3.5 and 3.6 years for the two samples. Fifty-seven percent of the 800 random lines in the 1945 sample and 65% of those in 1955 traced to foundation animals in ten flocks. Prominent animals and their relationship to the breed in 1945 included C-1659 (Mt. Haggin), 4.3%; and his sire 45215 (Blendworth Herriad), 3.2%. Eight rams had relationship of 4% or higher to the breed in 1955, *viz.*; 136101 (Bullet), 6%; 167072 (Keystone Valor), 5.5%; 154040 (Mr. Mitchell), 4.8%; C-1659, 4.7%; 167089 (Keystone Sensation), 4.6%; 45215, 4.2%; 117842 (B. and D. R. V. F. 98), 4.1%; and A-2267 (Bonny Leas 290), 4.0%.

5. EFFECT OF NURSING HABITS ON CALF WEIGHTS. T. C. Cartwright* and J. A. Carpenter, Jr., *Texas Agricultural Experiment Station, College Station.*

Nursing habits of calves were observed weekly during 4 consecutive weeks of June, 1960. Each observation period began at noon and ended 24 hours later, but only daylight observations were recorded. Little nocturnal nursing occurred. Six bull calves were paired so that each pair consisted of one Hereford and one Brahman-Hereford F_1 which were within 1 day of the same age. Their dams were Herefords within 2 years of the same age. The average diurnal nursing frequency and duration was greater for the crossbreds (4.2 times and 38.0 minutes) than for the Herefords (3.5 times and 28.7 minutes). There appeared to be no breeding type difference in time-of-day of nursing. The crossbreds averaged 46 lb. more at 180 days of age. In another phase of the study, lactation gains of 145 Hereford cows nursing either Hereford or crossbred calves were correlated with 180-day weights of their calves. The absolute magnitude of the correlation coefficient was greater for male calves (—.35) than for females (—.19) and greater for crossbreds (—.62) than for Herefords (—.20). The correlation was lowest for Hereford females (—.11) and highest for crossbred males (—.79). The pattern of correlations was interpreted as indicating that, as the calf obtains more milk from its dam, differences in her body weight are proportionately more dependent on this activity than on other influences. These observations may offer at least a partial explanation of the cause of sex differences and of heterosis in weaning weights. It appears that milk production may be affected not only by the genotype of the dam but also by the genotype of the calf.

6. PREDICTION OF BEEF CARCASS COMPOSITION AND VALUE. L. L. Christian*, M. L. Ogilvie, and E. R. Hauser, *University of Wisconsin, Madison.*

Eight live animal measurements were taken immediately preceding and 10 carcass measurements 48 hours after slaughter on 80 Hereford steers which had been fed varying lengths of time and received different levels of stillbestrol. A pooled within year, level of stilbestrol, and days on feed analysis was made to determine relationships between measurements and to find those measurements which gave the best prediction of pounds of carcass fat, pounds of carcass protein, loin eye area, weight of lean cuts, and wholesale value. Partial correlations holding weight constant showed only loin weight, lean cut weight and carcass grade to be significantly associated with carcass value. Carcass length, depth probe through the round, and live weight combined accounted for 63% of the variation in chemically determined fat. This was increased to 64% with the addition of carcass grade and to 66% with the addition of both carcass grade and carcass weight. Depth probe through the round, carcass weight, width of hooks, and 12th rib fat accounted for 86% of the variation in carcass protein. When loin eye area replaced depth probe the coefficient dropped to 85%. Probe width of round, carcass weight, shoulder width, live weight, and live grade accounted for 51% of the variation in loin eye area. These equations applied to an independent sample of 40 steers gave significant ($P<.01$) within group correlations between predicted fat and chemically determined fat of 0.69, 0.72, and 0.73 respectively. Those between predicted protein and chemically determined protein were 0.80 and 0.76 (both $P<.01$).

7. SOME FACTORS AFFECTING TENDERNESS OF BEEF. C. J. Christians*, R. L. Henrickson, R. D. Morrison, D. Chambers and D. F. Stephens, *Okla. Agrl. Exp. Sta. and AHRD, ARS, USDA.*

Tenderness studies were conducted during a three year period on 176 Angus carcasses from 43 heifers and 133 steers by 24 sires. The animals were self-fed the same growing ration to an average age of 386±24 days. The average carcass weight was 547 lb. and the average grade was low choice. In 1957 the 12th rib steaks from both sides of all carcasses were broiled. In 1958 the 8th and 12th rib steaks from the left side were broiled; those from the right side were deep fat fried. In 1959 the 8th, 9th and 12th rib steaks from both sides were deep-fat fried. Two 1-inch cores were obtained from each steak for shear force determination by the Warner-Bratzler technique. Analyses of variance for the 1959 data indicated that animals, sides, and ribs were the main sources of variation in tenderness. The 12th rib steaks were more tender than the 8th or 9th rib steaks and the dorsal cores were more tender than the lateral cores. Although a side x animal interaction existed, the left side generally was less tender than the right side. Correlations between chemical analyses and shear values were too small to explain the differences in tenderness which were observed between sides. Although sire differences were not statistically significant, intra-year, intra-sex heritability estimates for tenderness as computed by the paternal half-sib correlation method varied from 62 to 69% depending upon the amount of data involved.

8. CROSS-NURSING STUDIES IN SWINE. D. F. Cox* and R. L. Willham, *Iowa State University, Ames.*

Pigs from three litters farrowed on the same day by females of the same breed and age were ex-

changed within one day after farrowing. Four pigs of a litter as born were exchanged for two foster pigs from each of the other litters. Sexes were balanced where possible in the fostered pigs. Weights of individual pigs were taken at 0, 21 and 42 days of age. Eleven sets of three females each were established over a two week period in one farrowing season. Analyses of variance for body weight were done within the sets of three litters. Genetic differences between groups of full-sibs plus prenatal intrauterine effects were contained in differences between litters as born. Differences between females in their maternal influence on the body weight of nursing pigs plus environmental effects common to the pen where the litter was raised were contained in differences between litters as reared. The analysis gave no evidence for an interaction between these main effects in 21- and 42-day weight. Six percent of the variance at 21 days and 12% of the variance at 42 days was ascribable to differences between litters as born. Twenty and 23% of the variance at 21 and 42 days, respectively, was represented by differences between litters as reared. The remaining variance arose from differences among full-sibs raised on the same female. The technique appears to be a practical and useful means of separating the genetic and maternal components of traits in swine.

9. GAINS AND CARCASS TRAITS OF ANGUS, ZEBU AND ANGUS-ZEBU STEERS. T. M. DeRouen*, W. L. Reynolds, A. M. Mullins, R. F. Bouleware, and R. S. Temple, *U.S.D.A., A.R.S., and Louisiana Agricultural Experiment Station, Jeanerette.*

A study to evaluate growth and carcass quality of crossbred and straight bred yearling steers was conducted. The investigation included 13 Angus, 13 Brahman, 11 Sindhi-cross, 50 Brahman-Angus, and 37 Africander-Angus steers. The latter two groups were the progeny of *inter se* crossbred lines. The Sindhi-cross included 8 Angus x Sindhi and 3 Brahman x Sindhi steers. The steers were fed concentrates ad lib on pasture during the spring and summer 1958, 1959, and 1960. Daily gains were: Sindhi-cross, 1.80; Brahman-Angus, 1.79; Angus, 1.68; Africander-Angus, 1.67; and Brahman 1.61 lb. The Sindi-cross and the Brahman-Angus gained faster ($P<.05$) than the other breed groups. Carcass grades of the Angus and Sindhi-cross, 9.9 and 9.1, respectively, were higher ($P<.01$) than the other groups. Brahman-Angus, Africander-Angus and Brahmans were similar with carcass scores of 8.2, 8.0 and 7.7, respectively (av. standard=7, av. good=10). Chilled carcass weights were: Sindhi-Cross, 491; Brahman-Angus, 478; Africander-Angus, 456; Angus, 446; and Brahman, 435 lb. Carcass weights of the Brahman-Angus and the Sindhi-cross were heavier ($P<.05$) than the other groups. Rib-eye area for the Brahman-Angus was 9.8 sq. in., the Sindhi-cross, 9.7, the Africander-Angus, 9.5. These areas are greater ($P<.01$) than those of the Angus and Brahmans which measured 8.7 and 8.0 sq. in., respectively. Shear values of 1-inch cores disclosed that the Angus were more tender (15.5) followed by the Africander-Angus (16.6). These values are smaller ($P<.01$) than the Brahman-Angus and Sindhi-cross steers in this trait (19.0 and 19.7, respectively); Brahmans were least tender with a value of 25.8.

10. STREAMLINED HIND-QUARTER FOR CUTOUT IN BEEF CATTLE. Henry Elliott*, Dale W. Zinn, and Ralph M. Durham, *Texas Technological College, Lubbock.*

This technique was developed in an effort to establish a rapid, efficient method for determining the relative value of beef carcasses in terms of retail trimmed primal cuts. It is a method which might be used in the normal packing house process of preparing the carcass for the wholesale market. Thus, it could be effectively used for determining meat-type animals in cattle populations. The procedure of preparing the streamlined hind quarter is a complete "on the rail" operation. The carcass is quartered between the 12th and 13th rib in the normal manner. The flank, kidney and suet are removed, and the outside fat is trimmed to a desired specified thickness. The percent of the chilled carcass represented by the remaining round, rump, and loin with the shank is then computed. Since the three primal cuts remaining constitute a major part of the high priced cuts of the carcass, it is considered that this is a good indicator of carcass merit. A correlation coefficient of the streamlined hind quarter with the percent yield of primal cuts on 101 head of steers was .89.

11. EVIDENCE FOR GENETIC INFLUENCE ON APPETITE IN BEEF CATTLE. Noah England, James Brinks, Ralph Bogart* and R. T. Clark, *Oregon Agricultural Experiment Station, Corvallis, and Agricultural Research Service, U.S.D.A.*

A total of 290 beef calves from four genetically distinct lines have been used to determine the effects of year, sex, line and inbreeding of calf upon appetite as measured by feed intake. A pelleted ration consisting of two parts half cut alfalfa hay and one part concentrate was used for all animals in the study. Measurements of daily gain, daily feed consumption, and feed efficiency have been taken over a postweaning period extending from 500 to 800 lb. for all calves. The 300-lb. feeding period has been broken into four equal-length sub-periods of 75 lb. each and intraclass correlations between daily gain, feed efficiency, and daily feed intake have been determined. The regression of each of the dependent variables upon age at 500 lb. has also been determined. The sex of the calf had no effect upon daily intake when weight was held constant. There is a non-significant but consistent difference between inbred and non-inbred animals with the inbreds eating more at any given weight. Older calves at any given weight eat more, are less efficient and gain slightly more as shown by regression on age at 500 lb. There is a correlation of 0.345 between daily feed consumption and rate of gain. The correlation between daily consumption and efficiency is negligible (0.063). There are significant line differences in feed intake, indicating that intake is under genetic control. A heritability estimate of 0.384 further demonstrates genetic control of feed intake in this study.

12. PREDICTING WEANING TRAITS FROM BIRTH OBSERVATIONS IN BEEF CALVES. D. K. Flock*, R. C. Carter, J. A. Gaines, and B. M. Priode, *Virginia Agricultural Experiment Station, and U. S. Department of Agriculture, Blacksburg and Front Royal.*

Birth weight, seven linear body measurements at birth, type score at birth and weaning, and average

daily gain from birth to weaning were recorded in a group of 1425 beef calves of the Angus, Hereford and Shorthorn breeds, raised at the Beef Cattle Research Station, Front Royal, Virginia, during the years 1952 through 1957. The data were adjusted for age of dam, year and month of birth, and sex of calf. Analyses were made within breeds. Weaning type showed on the average a low negative correlation with birth weight and linear body measurements (−.00 to −.19; 0.09 to −.15; −.01 to −.21 in the Angus, Hereford and Shorthorn respectively). Type at birth and weaning were slightly positively correlated (0.26; 0.20; 0.08). Significant breed differences were found for phenotypic correlations involving average daily gain. Those with birth weight and linear body measurements were highest in the Angus and lowest in the Shorthorn, the Herefords being intermediate (0.15 to 0.33; 0.04 to 0.25; −.06 to 0.15). Birth type was essentially uncorrelated with preweaning gain (0.06; −.05; 0.11), while the relationship between weaning type and preweaning gain was lowest in the Angus and highest in the Shorthorn (0.32; 0.42; 0.55). Multiple regression analyses of weaning type and preweaning A.D.G. on seven linear body measurements at birth, as well as simple linear regressions on seven ratios of linear measurements revealed that the predictive value of body measurements at birth is not high enough to give a reliable early indication of a calf's merit.

13. CROSSING THREE BRITISH BREEDS OF BEEF CATTLE. J. A. Gaines, W. H. McClure*, R. C. Carter, and C. M. Kincaid, *Virginia Agricultural Experiment Station, Blacksburg.*

This experiment was designed to compare purebred, two-breed cross, three-breed cross, and backcross calves that were produced in the same years from purebred dams. In this way any differences observed would be due only to the genetic constitutions of the calves, and would not be confounded with differences between purebred and crossbred dams. Angus, Hereford, and Shorthorn cattle were involved. The three-breed cross and backcross calves were produced from purebred dams by using crossbred bulls. Traits of particular interest were percent calf crop, weight and grade at weaning, weight and grade at the end of full-feeding, and weights and grades of carcasses. Results to date show that 116 purebred matings resulted in 85 calves weaned (73%), 117 two-breed matings yielded 102 calves (87%), 113 three-breed matings gave 95 weaned calves (84%), and 117 backcross matings produced 105 calves at weaning (90%). This is a difference of approximately 14% livability between purebreds and crossbreds. Weaning weights in the four groups were 382, 394, 416, and 395 lb. Steer slaughter weights (139 head) were 1055, 1106, 1121, and 1069 lb.; heifer slaughter weights (148 head) were 743, 760, 802, and 784 lb. Carcass weights were 630, 662, 676, and 642 lb. in the steers and 440, 453, 475, and 464 lb. in the heifers. Weaning feeder grades, slaughter grades at end of feeding, and U.S.D.A. carcass grades did not indicate any differences between the four groups.

14. FACTORS AFFECTING GAIN AND CARCASS TRAITS OF ANGUS CATTLE. J. L. Gill* and L. N. Hazel, *Iowa State University, Ames.*

Records of 150 purebred Angus cattle were analyzed by least squares to evaluate the influence of environmental factors upon feedlot gains and carcass merit. Minimum selection was practiced among females and none among males. Feedlot gains were influenced to an important extent by season, initial age ($b=-0.007\pm0.002$) and initial weight ($b=0.005\pm0.001$). Carcass length and leg length were influenced by season and sex but not by age at slaughter. Carcass length was also affected somewhat by sires and to a high degree by carcass weight ($b=0.0096\pm0.0025$ in.). Carcass weight was the only apparent factor affecting circumference of round and rib eye area ($b=0.0178\pm0.0067$ in. and 0.015 ± 0.002 sq. in.). Carcass grade and marbling score were influenced by sire, season and sex. Length of feeding period and carcass weight affected fat depth ($b=0.0015\pm0.0005$ and 0.0016 ± 0.0005) and fat area over the rib eye ($b=0.009\pm0.002$ and 0.013 ± 0.002) to a high degree. Heifer carcasses were fatter than steers in depth (0.1 in.) and area (0.6 sq. in.). Inequality of subclass variances dictated using multiplicative factors to adjust carcass length for seasons. Intraclass correlations indicating repeatability of a trait considered as a characteristic of the dam were quite small except for feedlot gain ($r=0.11\pm0.10$) and fat area over the rib eye ($r=0.17\pm0.15$). The evidence suggests that fat area over the rib eye may be a more useful indicator of relative fatness than fat depth. Progeny test or other group comparisons, particularly with small numbers of offspring, can be made more accurately after adjusting for the important environmental factors.

15. EFFECTIVENESS OF SELECTION IN DIFFERENT ENVIRONMENTS. Carl T. Hansen*, C. S. Chung and A. B. Chapman, *University of Wisconsin, Madison.*

Selection for rate of gain from 3 to 9 weeks of age in the laboratory rat was practiced in two feeding regimes, (1) *ad libitum*, adequate diet (FF) and (2) limited amount (about ¾ FF), adequate diet (LF). Comparisons of the performance of progeny of selected parents were made by reciprocal transfer between these two regimes as well as in a third environment, *ad libitum*, limited protein (LP). Average genetic gain per generation was measured as the difference between the regression (of weight gain on generation number) of unselected progeny of selected parents and the comparable regression for the controls. Realized heritabilities, estimated from the ratio of the average genetic change to the average selection differential per generation, were 0.17 ± 0.03 and 0.14 ± 0.01 for the FF and LF stocks, respectively. The performance of the FF stock was superior to the LF stock when both were raised under the FF environment and under the LP environments (8.1 ± 1.8 gm. and 14.1 ± 2.2 gm., respectively, for the five generations in which reciprocal transfers were made). The LF stock gained more than the FF stock under the LF environment in four of the five generations of exchange (average difference $=2.5\pm1.5$ gm.). In all cases, the transferred stocks were superior to the controls in the foreign environment.

16. EXPRESSIONS OF HYBRID VIGOR IN BEEF CALVES. D. D. Hargorve*, M. Koger, F. M. Peacock, J. W. Carpenter and A. C. Warnick, *University of Florida, Gainesville.*

Two feeding trials were conducted comparing the performance of early-weaned Brahman, Shorthorn

and Brahman x Shorthorn calves. In each trial, eight calves of each of the three breed groups, with equal numbers of steers and heifers, were used. The calves averaged 85 days of age at the time of weaning, with a range from 39 to 120 days. The average weight at the time of weaning was 200 lb. The calves were individually fed twice daily with one-half of each breed-sex group being equalized fed concentrates at two percent of their body weight and the other one-half were full fed. The feeding periods were divided into two seasons; Season 1, June 1 to October 22 and Season 2, October 22 to March 15. The average daily gain and pounds of feed required per pound of gain were: Brahman, 1.50 and 6.55; Shorthorn, 1.37 and 6.95; and crossbred, 1.59 and 6.44. Breed and season were highly significant ($P<.01$) for rate of gain and there was also a significant ($P<.05$) Breed x Season interaction. There was no significant difference among the breed groups for efficiency of feed utilization. The equalized-fed calves were more efficient than the full-feds and both groups were more efficient in Season 1 than Season 2 ($P<.01$). The full-fed crossbreds and Shorthorns consumed significantly more feed ($P<.05$) than in the Brahmans. Chemical analysis of the 9–10–11th rib cut and specific gravity measurements of the right side of the carcass and 9–10–11th rib cut indicated the Shorthorns to have the fattest carcasses, followed by the crossbreds and Brahmans, respectively.

17. PRENATAL AND POSTNATAL EFFECTS IN RABBITS. Walter R. Harvey*, Robert B. Casady, A. E. Suitor and K. E. Mize, *United States Department of Agriculture, Beltsville, Maryland and Fontana, California.*

A preliminary crossnursing experiment with 32 pairs of does showed no effects of fostering on mortality, 21-day weight, 56-day weight or gain from 21 days to 56 days. Sex effects on growth to 56 days of age were also found to be non-existent. In the primary experiment, 20 sets of five to seven non-sib does were mated to non-sib bucks with all does in the same set being mated on the same day. Four does in each set with at least eight live kindlings each at birth and which kindled nearest the same time were selected for the experiment. Each doe in each set retained two of her own progeny and two were transferred to each of the other does in the set. All excess kindlings were transferred to other does not included in the experiment or they were destroyed. Prenatal effects which include one-half of the genic effects, accounted for none of the variability in mortality to 21 days and only 3% of the variance in mortality to 56 days. Postnatal maternal effects significantly affected mortality to both 21 days and 56 days accounting for 5% and 7% of the variation, respectively. Of the total variation in 21-day weight, postnatal maternal effects accounted for 27%, prenatal effects accounted for 17% and the interaction of postnatal and prenatal effects accounted for 5%. Postnatal maternal effects accounted for 12% and the prenatal effects accounted for 13% of the variation in 56-day weight. The estimate of the interaction component of variance for 56-day weight was slightly negative. Gain in weight from 21 to 56 days was influenced more by prenatal effects (10%) than by postnatal maternal effects (8%) or the interaction (4%).

18. INVITATIONAL PAPER—THE EFFECTS OF SAMPLING ERRORS ON THE EFFICIENCY OF SELECTION INDEXES. L. N. Hazel, *Iowa State University, Ames.*

19. GENETIC AND ENVIRONMENTAL CHANGES IN THREE STRAINS OF SWINE. H. O. Hetzer*, W. R. Harvey, C. O. Miller and R. L. Hiner, *U.S.D.A., Beltsville, Maryland and Miles City, Montana.*

Genetic and environmental changes between generations and years and changes in maternal effects associated with aging of dams have been measured in three randomly selected strains of swine. Two of the strains are at Beltsville, Md. and one at Miles City, Mont. The three strains are maintained by use of the repeat mating technique as described by Goodwin *et al.*, 1955, 1960. Four litter traits, two post-weaning measures of individual growth rate and six carcass traits have been studied. Results for the litter traits are based on four generations and those for individual pig traits on three generations. Least squares estimates of the three kinds of effects were obtained for each trait by both ignoring and considering differences between matings in the analysis. Genetic changes were unimportant except for 140-day weight which showed some improvement in one strain. Matings within generations differed significantly for five traits in one strain and for two traits in each of the other strains. Environmental changes between years appeared important for 140-day weight and daily gain in the Miles City strain and for eye muscle area, % fat cuts, % lean cuts and % bacon in the Beltsville strains. Maternal effects associated with aging were not apparent for any of the traits in the Miles City strain, but litters from two-year old sows in the Beltsville strains showed important advantages in both litter size and litter weight at birth and at weaning as well as in post-weaning growth rate.

20.

21. BLOND MINIATURE SWINE FOR RADIATION RESEARCH. V. G. Horstman*, J. W. Cable, W. J. Clarke, M. E. Kerr, R. L. Persing and L. K. Bustad, *General Electric Company, Hanford Laboratories Operation, Biology Laboratory, Richland, Washington.*

Three years ago a limited project was started at Hanford designed to develop a blond miniature pig for use in some of the radiation studies. The principal advantage of such an animal is its suitability for certain skin radiation studies where the animal is to be observed over a lifetime. The foundation stock for this strain was the Pitman-Moore miniature, the Palouse breed developed by Washington State University, and a blond swamp swine obtained from Louisiana. A few blond swine that are 7/8 and 15/16 miniature are now available. Their growth pattern approximates that of the Pitman-Moore Miniature with a predicted adult size of about 70 kg. under our dietary regimen. Growth patterns and photographs of these swine will be presented. These swine are now being utilized in studies involving the acute and long-term effects of intradermally injected plutonium. The skin changes produced in these animals are readily evident, they are able to survive multiple anesthesia and will remain small throughout their lifetime.

22. MEASURING WOOL FIBER LENGTH WITH WIRA MACHINE. M. E. Hourihan*, W. R. Harvey and C. E. Terrill, *U. S. Department of Agriculture, Beltsville, Maryland.*

Individual fiber length was measured in four wool grades by ruler and by the WIRA developed by the Wool Industries Research Association. Two operators measured unstretched and stretched length by ruler and duplicate lengths by WIRA. Each operator pulled and measured two fibers from each of two levels (1/3 and 2/3 from the base) of each of 25 locks for each grade and also measured those pulled by the other operator. Analyses of variance with variance component estimates, expected standard errors, and certain means, were computed separately for each grade. Although variance component estimates were generally larger for stretched than for unstretched measurements there was little difference between the methods expressed as percent of the total or as percent standard error of the mean. Average WIRA measurements, their variance component estimates, and standard errors of the means agreed more closely with stretched than with unstretched ruler measurements for all grades. Standard errors as a percent of the mean were larger for the WIRA than for either ruler measurement. Differences among pulling operators, levels and their interactions were generaly small and insignificant. Measuring operators differed significantly and interacted with the Ruler vs. WIRA classification. Their differences were larger with the ruler but still existed with the WIRA. WIRA measurements recorded to 0.5 cm seem to contain considerable rounding error. A method of measuring fiber length with the WIRA developed from this study involves two operators, each pulling and measuring 8 fibers from one level of each of 50 representative locks from a lot or fleece.

23. CONGENITAL HYDROCEPHALUS IN AYRSHIRES. Keith Huston*, F. E. Eldridge, and F. H. Oberst, *Kansas State University, Manhattan.*

Calves with varying degrees of hydrocephalus have been observed among the progeny of four related Ayrshire bulls. Affected calves sired by one typically were premature (about 45 days) stillbirths with normal sized noses but abnormally large craniums. Affected calves sired by another typically were either dead at birth, or weak at birth and died shortly thereafter. In the latter, the degree of internal hydrocephalus was often so slight that the head appeared normal; an inability to fully coordinate movements was displayed by some calves. In comparison with cases previously reported in Holsteins, the osteological changes in these were not so pronounced. The skull was not asymmetrical nor were the humeri and femurs shorter than normal. In the brain, abnormalities in the cerebral hemispheres, the cerebellum, the corpora quadrigenia and other parts were noted. Although not conclusive, the available evidence supports the hypothesis of a simple recessive mode of inheritance.

24. INVITATIONAL PAPER — EVALUATING MEAT QUALITY AFTER IT REACHES THE TABLE. C. M. Kincaid, *Agricultural Research Service, U.S.D.A., Beltsville, Maryland.*

25. PROGENY TESTING IN TROPICAL FEED LOTS AND PASTURES. Joel Maltos*, Carlos Aguilar, Max Laredo and Jorge De Alba, *Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica.*

Over a 3-year period the performance of 102 weaned heifer and bull calves sired by 10 bulls, has been studied. During 1958–59 bull calves were on pasture for 100 days and then for 87 days in the feed lot. During the next 2 years progeny of both sexes were tested simultaneously on the same Pará *(Pannicum purpurascens)* grass pastures and in the feed lot. Test periods were 126 and 154 days respectively, with data adjusted for sex. The only significant differences between sires for rate of gain were during 1958–59, when the lowest gaining progeny on pasture made highest gains in the feed lot. Difference between environments was highly significant the second year. During 1960–61 interaction between sire and environment was significant at the 5% level. Each year, correlations between gain and efficiency of gain were significant. The relationship of initial weight to gain and to final weight varied with year and environment. Some of the sires were tested for 2 consecutive years. The merit of the sires, based on the performance of their progenies, differed from one year to another and between environments. Our short experience indicates that serious mistakes could be made in selection, since some sires show a strong interaction between environment and genotype. This poor repeatability places doubt on the advisability of recommending pasture performance testing by farmers. Feed lot testing does not solve the problem in tropical areas.

26. CROSSBREEDING SYSTEMS IN BEEF CATTLE. M. Koger*, R. W. Kidder, F. M. Peacock, W. G. Kirk and M. W. Hammond, *University of Florida, Gainesville.*

Brahmans, Devons, and various crosses of these two breeds were utilized in a ten year trial designed to study crossbreeding schemes. Weaning weights were 340, 397, 399, 393 and 375 lb., respectively, for straightbreds, F_1 crosses, backcrosses out of F_1 dams, crisscrosses, and progeny from inter-se mating of crossbreds. The corresponding weights at 18 months of age were 607, 696, 651, 654 and 611 lb. Data from two other experimental herds show similar trends at weaning for the crosses represented. Results from one experimental herd and a private cooperator's herd confirm the marked decline in hybrid vigor in inter-se mating of crossbreds.

27. INVITATIONAL PAPER — PUREBRED VS CROSSBRED SELECTION SCHEMES WITH DROSOPHILA. Ken-ichi Kojima, *University of North Carolina, Raleigh.*

28. SOME CAUSES OF VARIATIONS IN THE CALVING INTERVAL. J. F. Lasley*, B. N. Day, J. E. Comfort and R. Subramanian, *University of Missouri, Columbia.*

Production records on 262 grade Hereford cows in a Missouri commercial herd over a 10-year period were studied. The average calving percent for mature cows wintered was 98.6, and 93.3% of these cows weaned calves. Death losses in mature

cows averaged about one percent per year and the percent of cows sold varied between 10 and 15 per year. The main reasons for selling cows were age and poor performance records. The average calving interval was 356.34 days with a standard deviation of 31.31 and a coefficient of variation of 8.79%. Neither the sex of the calf suckled or the age of the cow significantly influenced the length of the calving interval, but it was significantly influenced ($P<.005$) by the year of calving and the bulls to which the cows were exposed during the breeding season. The within season correlation between calving interval and weaning weight was $-.09$ ($P<.05$). The between season correlation coefficient for these two traits was 0.99 ($P<.01$).

29. SOME FACTORS INFLUENCING WEIGHT AND GRADE OF BEEF COWS. Thomas J. Marlowe* and Joseph B. Graham, *Virginia Agricultural Experiment Station, Blacksburg.*

Data included weight, grade, condition, season, and nursing status on 993 Angus and 835 Hereford cows, 16 months to 18 years old (919 over 6 years), in 12 Angus and 13 Hereford herds. Least squares estimates of the effects studied indicated a breed difference; therefore, all estimates are within breeds. These factors accounted for 61.88% and 67.92% of the total variation in weight and 32.40% and 29.00% in grade among Angus and Herefords, respectively. Age has greatest influence on weight among younger cows, but condition was more important among older cows. Angus cows attained a higher percentage of their final mature weight by 18 months, but were lighter than Hereford cows at all older ages. Nursing and/or season had little influence on weight when adjusted for differences in condition, but accounted for a fairly large fraction of the variance when condition was ignored. Very thin cows weighed 136 and 213 lb. less and fat cows 218 and 181 lb. more than Angus and Hereford cows, respectively, in average condition. Age had little influence on grade (1.68% and 2.13% among Angus and Herefords, respectively); however, grade increased slightly among the Herefords and decreased slightly among the Angus as they approached maturity. There was essentially no difference in average grade between breeds. Largest influence on grade was condition, which accounted for 22.46% and 19.87% of the variation among Angus and Hereford cows, respectively. Very thin cows graded 1.2 and 1.6 points lower and fat cows 1.7 and 1.2 points higher than average condition cows.

30. SOMATIC CHROMOSOMES OF THE PIG. J. L. McConnell*, N. S. Fechheimer, and L. O. Gilmore, *Ohio Agricultural Experiment Station, Wooster and Ohio State University, Columbus.*

The chromosome complement of the pig was studied both quantitatively and morphologically using cultured leucocytes from eight animals. Blood from male and female Yorkshires, Poland Chinas and Hampshires and a Duroc male was used. Samples were collected at time of slaughter. The erythrocytes were agglutinated and removed by centrifugation. The leucocytes remaining in the serum were cultured for three days in a prepared medium. Prior to harvest of the cultured cells, colchicine was added to the culture bottles. Cells were harvested by centrifugation, treated with a hypotomic saline, and fixed in acetic-alcohol. A drop of the fixative, containing the cells in suspension, was put on each slide, the slides were air-dried rapidly and stained by the Feulgen procedure. Chromosome counts were made from 124 peridiploid cells. Of these cells, 1.6% contained <37 chromosomes, 4.8% contained 37, 66.9% contained 38, 12.1% contained 39, 13.7% contained 40 and 0.81% contained 42. A few haploid and polyploid cells were seen in addition. From enlarged photographs of the better cells, a tentative karyotype was made using chromosome length and centromere location as the criteria of pairing. Most of the cells studied contained a large sub-metacentric pair, 5 large acrocentric pairs, 3 medium sized metacentric pairs, 6 medium sized sub-metacentric pairs, 3 small sub-metacentric pairs and 3 small acrocentric pairs. Sometimes additional small chromosomes were seen, accounting for the quantitative variations observed. The Y chromosome was tentatively identified as a small acrocentric and the X as a small metacentric chromosome.

31.

32. BREEDING-MANAGEMENT INTERACTIONS IN SWINE. I. T. Omtvedt* and J. A. Whatley, Jr., *Oklahoma State University, Stillwater.*

A total of 240 pigs from three lines of breeding (OK14, 14x8–9 and OK3 or OK8) were raised under two management systems to investigate the occurrence of genotype-environment interactions. Trials I and II (spring and fall, 1959, respectively) included three replication of 24 pigs each, while four replications of 24 pigs were used in Trial III (spring, 1960). The two management treatments were a self-fed, free-choice, shelled corn and simple supplement ration on pasture and a self-fed, pelleted, vitamin-antibiotic fortified ration on concrete (12 pigs per pen). Pigs were allotted to the management systems at weaning (56 days) and continued on test until they averaged approximately 208 lb. live weight. Line of breeding-management interactions were generally insignificant for the traits studied. No significant line of breeding-management interactions were detected for average daily gains, but this interaction was significant at the 10% level of probability for probed backfat thickness in Trials II and III. Line of breeding-management interactions were observed for dressing percentage in all trials and for carcass backfat thickness in Trial II. In general, pigs raised in confinement on the pelleted rations gained faster, had more backfat, larger loin eye area, heavier belly, higher dressing percentage and a higher yield of primal cuts than pigs fed the free-choice, shelled corn and supplement ration on pasture. Pasture raised pigs were sounder on their feet and legs than those raised in confinement. Line of breeding differences were observed for rate of gain, backfat thickness, length, belly weight and loin eye area.

33. RANGE PERFORMANCE OF PROGENY OF MILES CITY SIRES. O. F. Pahnish*, J. S. Brinks, R. T. Clark and J. R. Quesenberry, *Arizona Agricultural Experiment Station and U.S.D.A.*

Nine sires from the U. S. Range Livestock Experiment Station at Miles City, Montana and eight sires from private sources were progeny tested in

the Apache Tribal Herd at San Carlos, Arizona over a three-year period. The Miles City sires were from lines 1, 6, 9 and 10. Weaning weights and conformation scores were analyzed by least squares procedures including multiple range tests and orthogonal contrasts. Both weights and scores differed ($P<.05$ to $P<.01$) among years, age-of-dam classes and sires. Differences in weaning age significantly affected weight only ($P<.01$). Bull calves were 32 pounds heavier than heifer calves ($P<.01$), but heifer calves scored about one-fourth of a grade higher than bull calves ($P<.01$). Although sex X year and sex X age-of-dam effects on weight were non-significant, there were consistent indications that sex differences were magnified by favorable forage conditions and increases in availability of milk. The sex X year effect on score was significant ($P<.01$), but the sex X age-of-dam interaction was nonsignificant. Progeny groups by Miles City line 1 sires differed in weaning weight ($P<.05$). There were no significant differences among scores of progeny groups by sires from any given Miles City line. Calves by line 9 sires were 21 lb. heavier than those by line 10 sires ($P<.05$). Weights of the calves by line 1 and line 6 sires were between the aforementioned extremes. Progeny groups sired by the bulls from private sources differed in weaning weight ($P<.05$ to $P<.01$) and conformation score ($P<.05$). The average weights and scores of all calves by the nine Miles City sires were essentially the same as the weights and scores of all calves by the other eight sires tested.

34. PREDICTING FEED EFFICIENCY OF BEEF BULLS. N. N. Pepito, D. Chambers*, J. V. Whiteman and D. F. Stephens, *Oklahoma Agricultural Experiment Station and AHRD, ARS, USDA.*

Some factors which affect the amount of feed required per unit of gain were determined from data obtained from 242 bulls dropped during the spring of 1954 through 1959 at Ft. Reno. These calves were not creep-fed. They were weaned and started on feed at an average age of 216 days and they were individually self-fed a complete mixed ration containing approximately 63% TDN for 154 days. The amount of feed per unit of gain was affected by years, lines and sires. Intra-year, intra-line, intra-sire phenotypic correlations between feed requirement per unit of gain and pre-weaning daily gain, feeder score, average weight on test, and average daily feed-lot gain were 0.334, 0.316, 0.265 and —.429, respectively. Fifty-six percent of the variation in feed requirement was accounted for by age at weaning, average weight on test, and average daily gain on feed. The estimating equation was: Predicted pounds of feed per 100 lb. of gain equals 536.6 plus 1.10 times weaning age in days plus 0.80 times average test weight minus 225.21 times average daily gain on test. The addition of birth weight, preweaning daily gain and feeder grade to this equation did not appreciably increase the precision of the estimation. Using the equation above, the feed requirement was estimated for 32 bulls which were dropped in 1960 and handled like those dropped in prior years. The correlation between actual and predicted feed requirement for these bulls was 0.56, and eight of the ten bulls predicted to be most efficient were in that group.

35. COMPARISON OF CARCASS TRAITS OF ANGUS AND HEREFORD STEERS. Dallas Powell*, Wendell Kent, Henry Elliott, and Dale W. Zinn, *Texas Technological College, Lubbock.*

Forty-eight Hereford steer calves and 48 Angus steer calves were fed 185 days, slaughtered and compared for performance and carcass traits. No breed difference was observed in feedlot performance. Angus steers had significantly lighter hides (12 lb.) and significantly greater yield (0.6%). The difference of 0.7% between hide difference and dressing percent difference indicates that the Herefords had less non-hide offal than did the Angus. Angus also had significantly larger rib eyes, but back-fat was equal. Herefords had significantly more meat in the high priced cuts, both bone in and bone out. No difference was observed in tenderness as measured by the Warner-Bratzler shear. The "fat cuts" were analyzed and the Herefords had significantly less kidney, plate and flank. This analysis indicated that the superior Angus conformation scored by the U.S.D.A. grader actually was related to poorer cutout and that the superior Angus marbling did not result in more tender meat.

36. MASS SELECTION AND COMBINING ABILITY IN MICE. Gunther W. Rahnefeld, William J. Boylan* and R. E. Comstock, *University of Minnesota, St. Paul.*

One of the purposes of this work was to observe the extent to which genetic change in a population under mass selection is reflected in crossbreds obtained when that population is crossed with another. The S-line was derived from a cross of two highly inbred lines. Mass selection for weight increase from 18 days (weaning) to 42 days of age was initiated among individuals of the F_2 generation and has been continued for 11 successive generations. The A-line (not used in founding the S-line) is highly inbred. It derived from a pair of mice that resulted from over 60 generations of full-sib mating. However, during this experiment it has been carried as a closed population without further continuous close mating. This line provided the *control* population and was continuously crossed to S-line males to provide SxA crossbreds. Each generation each S-line male (20–25) used for breeding was mated to 3 S-line females and 2 A-line females. The performance of crossbred offspring *was not* employed as any part of the basis for selection in the S-line. S-line performance has shown continuous improvement. The difference between S and control line lines has increased 3.87 grams. The change has been essentially linear with time, shows no indication of an approaching plateau and agrees well with prediction based on heritability. Crossbred (SxA) performance appeared sharply improved following one generation of selection. However, there has since then been no indication of further improvement in crossbred performance.

37. MEATINESS AND FEEDLOT TRAITS OF SHEEP PROGENIES, C. V. Ross, W. H. Sellers *, and S. E. Zobrisky, *University of Missouri, Columbia.*

The progeny of four outstanding Hampshire rams were compared from birth to time of slaughter. After grazing during the summer the lambs were individually fed in dry lot until they reached 96–

100 lb. and graded low choice, alive. Economic and carcass data were obtained and analyzed for variation among sires, between sexes, and between twin and single lambs. Analysis of variance indicated that the difference among sires was highly significant for untrimmed leg ($P<.005$), untrimmed shoulder ($P<.01$) and trimmed shoulder ($P<.025$). Birth weight ($P<.025$), weaning weight ($P<.05$) and wool weight ($P<.05$) differences were also significant. Loin eye area and efficiency of gain differences approached significance ($P<.09$) as did trimmed rack ($P<.10$). Differences in rate of gain were not significant. High correlations between traits ($P<.01$) were observed in the following for both single and twins, respectively: rate and efficiency of gain ($r=-.82$ and $-.70$) weight of leg and loin eye area, ($r=0.70$ and 0.57), weight of untrimmed shoulder and loin eye area ($r=0.61$ and 0.64), weight of trimmed shoulder and loin eye area ($r=0.63$ and 0.58), and weight of trimmed loin and loin eye area ($r=0.61$ and 0.91). These data show that there are significant differences in progeny even among outstanding rams.

38. GENETIC-ENVIRONMENTAL STUDY OF CALF GROWTH. S. W. Sabin, P. O. Stratton and Ralph Bogart, *University of Arkansas, Fayetteville.*

Total gain, test gain, and final weights of 330 University of Wyoming beef calves of three breeds, born from 1953–1957, were analyzed to determine the influence of line, age of dam, sex, year, and age at weaning when either, neither or both birth weight and suckling gain differences were eliminated. Multiple regression values were highest in all cases when both birth weight and suckling gain differences were excluded in the analyses. Two-year-old dams were consistently the mothers of the slowest growing calves but no decline resulted with advanced age. Some indications of increased test gains as a result of low suckling gains were noted. Males consistently outgained females. Breed differences were large. Maximum genetic variance was found when birth weight and suckling gains were ignored. Adjustment of suckling gains decreased genetic variance more than adjustment of birth weight. Birth weight adjustment in test gain resulted in an increased genetic variance indicating a negative genetic correlation existed in these data between birth weight and test gain. High genetic correlations were found between the three traits studied.

39.

40. RATE OF GAIN AND FEED EFFICIENCY WITHIN SPECIFIC WEIGHT INCREMENTS IN GROWING BEEF CATTLE. Gary Smith, C. C. O'Mary and M. E. Ensminger, *Washington State University, Pullman.*

Forty-seven purebred heifers and bulls fed an all pelleted ration were used to study rate and efficiency of gain and their correlations during a 150-day time-constant test, and within 100 lb. live weight increments. For both heifers and bulls, feed efficiency decreased as live weight increased. The feed requirements for bulls, per 100 lb. of gain for the 500–600, 600–700 and 700–800 lb. groups were 580, 723 and 755 lb. and for heifers in the 400–500, 500–600, 600–700, 700–800 and 800–900 lb. groups were 672, 774, 806, 907 and 915 lb., respectively. The average daily gains for heifers from 400 through 900 lb. by 100 lb. increments were 1.71, 1.72, 1.81, 1.66 and 2.05, respectively. Average daily gains for bulls by 100 lb. increments beginning at 400 lb. were 2.21, 2.33, 2.22, 2.38, 2.36, 2.15 and 3.74. Correlation coefficient between rate of gain and feed efficiency for bulls for the total period was $-.90$ with 5 degrees of freedom while correlations within increments of 500–600, 600–700 and 700–800 lb. were $-.81$, $-.96$ and $-.89$ with 5, 5 and 3 degrees of freedom. In heifers, the correlation coefficient for the time-constant test was $-.41$ with 19 degrees of freedom while correlations within increments of 400–500, 500–600, and 600–700 lb. were $-.88$, $-.90$ and $-.88$ with 10, 14 and 8 degrees of freedom, respectively. Thus in heifers, rate of gain and feed efficiency were more highly correlated within all weight groups than in the time-constant test.

41. STUDIES ON BRACHYGNATHIA IN DAIRY CATTLE. S. T. Smith*, Keith Huston, F. E. Eldridge, and J. W. Mudge, *Kansas State University, Manhattan.*

The inheritance of brachygnathia is being studied with breeding trials in four dairy breeds. In animals affected by this abnormality, the incisors meet posterior to the dental pad. A Jersey bull, known to sire affected animals, was mated to two parrot jaw Jersey cows and sired two normal heifers. When bred to these two and one other daughter, all calves were normal. Six parrot jaw and three normal offspring have resulted from nine affected X affected Guernsey matings. These offspring were mated among themselves. One normal X normal mating produced a normal calf. Affected X affected matings produced three parrot jaw and no normal, and four affected X normal matings produced four affected calves. In Brown Swiss, affected X affected matings resulted in one parrot jaw and two normal offspring. Two crosses between a parrot jaw Holstein and an affected Guernsey produced two normal calves. Two affected Jersey cows were mated eight times to parrot jaw Guersneys and eight normal calves resulted. When crossed with affected Guernsey bulls these normals produced five normal and three affected offspring. Four parrot jaw calves have resulted from mating the three animals with parrot jaw Guernseys. The data in Guernsey indicates that the inheritance is not extremely complex, but is more than just a simple recessive. The same genes do not seem to be involved in all breeds. Measurements on live animals and macerated heads show some shift in skull and mandible dimensions, but not completely out of the normal range of variation.

42. STUDY ON WOOL IMPROVEMENT IN NATIVE KIVIRCIK SHEEP OF TURKEY. Resit Sönmez*, *University of Ankara, Turkey.*

The majority of sheep raised in Turkey consist of native breeds with coarse and mixed wool. This type of wool is not suitable for textile industry. Turkey imports fine wool, exports carpet wool. The native Kivircik breed produces more fine wool than other native sheep. One project was aimed at crossing native sheep with German Merinos of Mouton type. This project could not be carried out successfully. The first crosses have more vigor and greater growth rate than the native sheep, but backcrosses to Merino rams result in poor growth and lack of vigor.

It was necessary to find ways to improve wool quality of the native sheep without crossing them with German Merinos if the poor environmental conditions were not changed. In the Kivircik sheep flocks there is a genetic variation in wool fineness and uniformity. Since the heritabilities of these characters are high, it is possible to produce rather fine and uniform wool by careful and continuous selection. A foundation flock had an average fleece of 48'S–50'S. In the third generation, heavier and quite uniform fleeces (about 58'S) were obtained. This showed that native Kivircik sheep can be improved to produce fleece of 58'S–60'S in four generations. Since these sheep are adapted to the natural and environmental conditions of this region the breeders will prefer this new improved Kivircik rather than Merino Crossbreds.

43. FACTORS AFFECTING GRADES OF PUREBRED AND CROSSBRED CALVES. John S. Sullivan*, Jr., Robert S. Temple and Barton R. Farthing, *Louisiana State University, Baton Rouge.*

Feeder grades, slaughter grades and weaning weights were recorded on 600 purebred and crossbred calves weaned at 250 days standard age. Estimates of the effect of breed of sire, breed of dam, age of calf, age of dam, sex and weight were calculated. Angus cows produced calves scoring 0.65 and 0.35 higher in feeder and slaughter grades respectively, than Brahman cows ($P<.05$). Calves from Hereford and Brangus cows graded slightly lower than calves out of Angus dams, but higher than Brahman cows. Six-, seven-, eight-, nine- and ten-year-old cows produced calves grading the highest, while calves out of three-, four- and five-year-old cows graded the lowest. Atlhough feeder grades were found to decrease significantly (—.01 points) as age of calf increased, slaughter grade was not significantly affected. The effect of weight at weaning on feeder and slaughter grade was highly significant. Feeder and slaughter grade increased 0.018 and 0.020, respectively, for every one pound increase in weight. Hereford, Shorthorn and Angus bulls sired calves averaging ¾ of a feeder score above the Braham-, Brangus- and Charolais-sired calves. The Hereford x Brangus and Angus x Brangus crosses had the highest mean uncorrected feeder and slaughter grades. Calves sired by Hereford bulls had the highest feeder grade at weaning with the Brangus- and Charolais-sired calves being the lowest. The affect of sex on feeder and slaughter grade was highly significant ($P<.01$). Heifers scored 0.90 and 1.28 points higher than steers at weaning for feeder and slaughter grades, respectively.

44. SELECTION FOR RATE OF GAIN IN MICE. T. M. Sutherland* and D. Pettus, *Colorado State State University, Fort Collins.*

Mice have been selected for five generations on their ability to gain in body weight between the ages of 4 weeks (weaning age) and 11 weeks, a period of the growth curve approximately that over which beef cattle are "performance tested." Three replicate lines of 15 litters by five sires in each line, standardized at birth to eight mice per litter, are carried, plus a like-sized control. Mice are individually fed a standard Purina pellet diet during the test period and records of feed consumption are kept. Composition of the weight gain is determined from random samples of five mice per line per generation at each of 16 weeks and 21 weeks of age. "Mature weight" is difficult to determine in mice, but a 150-day weight is taken to approximate this. Total gain has increased over the generations as a result of the direct selection pressure; "realized heritabilities" average in line 1, 23 (males), 0.66 (females); in line 2, 0.15 (males), 0.10 (females); in line 3, 0.22 (males), and 0.11 (females). Weaning weight is, however, thus far decreasing steadily, even more than should result from slight (correlated) negative selection pressure. Correlations between weaning weight and total gain in the test were highly negative in all lines (as high as —.68) in the first generation and have subsequently remained generally negative though not highly so. Feed consumption is dropping, indicating increasing efficiency.

45. GENETIC AND ENVIRONMENTAL EFFECTS IN PUREBRED AND BACKCROSS CALVES. R. S. Temple*, J. S. Sullivan, Jr., B. R. Farthing, and G. L. Robertson, *Louisiana State University, Baton Rouge.*

Records on 340 straight-bred Angus, Brahman, Hereford and backcrosses involving the four above breeds in addition to Charolais and Shorthorn were analyzed. Birth weight, weaning weight, feeder grade and slaughter grade were analyzed for differences between years, breed of sire and breed of dam within year. Constants were first fitted for sex and age of calf and age of calf and age of dam and the data were adjusted to a steer basis, a seven-year-old dam basis and to the average of all calves. After these adjustments were made, an analysis of variance for each trait was made. The year x breed of dam within sire interaction was found to be non-significant. The means of the adjusted data were then analyzed for differences in years, breed of sire, breed of dam within sire and the year x breed of sire interaction. These data indicate that the breed of sire ranked differently in different years for birth weight, feeder grade and slaughter grade. No significant differences were found for weaning weight between years or between breeds of sire, but there were significant differences between breed of dam within sire The 3/4 Charolais–¼ Brahman calves averaged the heaviest at weaning time. These were followed by ¾ Angus–¼ Brahman and ¾ Shorthorn–¼ Brahman, indicating the influence of Brahman breeding in the dam. The ¾ Hereford–¼ Brahman calves graded the highest both in feeder grade and slaughter grade.

46. PROGENY TESTS OF SIRES WHEN USED OVER LARGE AREAS. N. R. Thompson*, V. L. Baldwin, G. C. Graf, *Virginia Polytechnic Institute, Blacksburg.*

Early work by Lush (J. Dairy Sci. 14: 209, 1931.) showed that the accuracy of a progeny test could be improved by increasing the number of progeny. Lush and McGilliard (J. Dairy Sci. 38: 163, 1955.) showed that the effect of increasing the number of progeny was to reduce the random error, but that the bias which might have been introduced by non-random environmental effects would not be changed. If a sire's progeny are located and production tested in a random sample of geographic areas, we may assume

that no additional bias (over that existing within each area) will appear in the mean phenotypic performance of these progeny. However, the random error may increase, and, in order to maintain a constant level of accuracy in the progeny test, it will be necessary to use a greater number of progeny than would be needed in one area alone. Our research with random samples of milk and fat records from several states shows that the phenotypic variance increases by 3.4 to 8.2% for milk yield and 8.5 to 11.1% for fat yield when the effect of states is added to within-state effects. Therefore, it seems desirable to use approximately 5 to 10% additional progeny to evaluate a sire whose progeny have made their records in several states.

47.

48. EVALUATION OF THREE PLANNED MATING SIRES. L. D. VanVleck, H. W. Carter*, and C. R. Henderson, *Cornell University, Ithaca, New York.*

A comparison was made between records of daughters of three Holstein sires used artificially in planned mating programs and records of their dams in order to determine the influence of selectivity of mating on sire evaluation. The number of daughter-dam sets ranged from 33 to 44. The results showed that all three sires were mated to cows in above average herds. One sire was mated to cows which averaged above their herd mates by 599 lb. of milk and 31.6 lb. of fat. The other sires were mated to cows averaging nearer to their herd mates: —285 lb. of milk and —1.7 lb. of fat, and 334 lb. of milk, 0.5 lb. of fat respectively. Selection index estimates of daughter superiority were only slightly changed when dam records were considered in addition to daughter records even for the sire mated to cows averaging considerably above their herd mates.

49. FACTORS AFFECTING WEIGHT AND SCORE OF CROSSBRED CALVES. E. H. Vernon, W. R. Harvey* and E. J. Warwick, *ARS, United States Department of Agriculture, Beltsville, Maryland.*

Crossbreeding experiments using Brahman, Africander and European breeds of cattle were initiated at the Iberia Livestock Experiment Station in 1916. Analyses of data collected from 1932 to 1955 show that age of dam, date of birth and sex of calf have significant effects on birth weight, 180-day weight and 180-day score. A least squares method of fitting constants was used to evaluate the effects of these factors. To determine if the factors studied varied with the percentage of Brahman or of Africander ancestry the data were divided into seven groups based on ancestry. Interaction of sex with environment was measured by dividing the data for each of the 24 years studied, by year, equally into a high and a low group based on the yearly averages of 180-day weights. The effects of age of dam on six months weight of calf have proven to be greater in poor years than good, consequently the use of multiplicative correction factors is not warranted. On the other hand, in these studies, the effects of sex on six months weight are best adjusted with multiplicative correction factors.

50. GENETIC DIFFERENCES IN PREWEANING WEIGHTS OF SWINE. R. L. Willham* and D. F. Cox, *Iowa State University, Ames.*

The relative importance of genetic differences affecting preweaning weights in 267 litters of Duroc and Hampshire swine was investigated. Genetic differences common to full-sib litter mates were separated from environmental causes of likeness by using 119 pairs of litters related as double first or maternal first cousins. Weights were taken every seven days from birth to weaning at 42 days of age. The correlation among full-sibs was 0.33, 0.43, 0.45, 0.42, 0.46, 0.51, and 0.51 for birth, 7, 14, 21, 28, 35 and 42 days respectively. The correlation among full-sibs ascribed to genetic differences was 0.08, 0.21, 0.29, 0.21, 0.18, 0.17, and 0.00 respectively. Both genetic differences caused by genes of the individuals and genetic differences caused by genes of the dams of the individuals for maternal performance could be affecting this correlation. Presumably most of the genetic differences at 7, 14, and 21 days are differences in maternal performance since genetic differences of individuals are known to be relatively unimportant early in life. These data indicate that genetic causes of likeness among full-sibs decrease in importance from 14 to 42 days. This suggests that either genetic differences in maternal performance are becoming less important as age increases or that there may be a negative genetic correlation between maternal performance of the dam and the individual growth of her offspring during the late preweaning period.

50a. INVITATIONAL PAPER—STANDARDS FOR CARCASS SHOWS. R. W. Bray, *University of Wisconsin, Madison.*

51. INFLUENCE OF AGE ON THE CARCASS CHARACTERISTICS OF BARROWS AND GILTS. W. H. Bruner and B. D. VanStavern*, *Ohio State University, Columbus.*

A study was made of 1,174 barrow and 1,259 gilt carcasses from the Ohio Pork Improvement program. These barrows and gilts varied in age from 126 to 185 days of age at 200 lb. and were grouped for analysis into three age groups as follows: Group I, 126–145 days; Group II, 145–165 days; Group III, 166–185 days. Important carcass characteristics were analyzed for their relationship to age groups. No statistically significant difference exists between age groups for backfat, carcass length, loin eye size or percent lean cuts for barrows. However, loin eye size and percent lean cuts are significantly correlated with the age group for gilts. As gilts mature the loin eye tends to be larger and the percentage lean cuts greater. These observations indicate the importance of the sex of the individual in evaluating carcass information as a tool for the selection of breeding stock.

51a. INVITATIONAL PAPER—BEEF CARCASS STANDARDS FOR PRODUCTION REGISTRY. O. D. Butler, *Texas Agricultural Experiment Station, College Station.*

52. IMPORTANT BEEF CARCASS TRAITS EASILY OBTAINED. O. D. Butler*, L. E. Kunkle, F. A. Orts, G. T. King and T. C. Cartwright, *Texas Agricultural Experiment Station, College Station, and Ohio State University, Columbus.*

The boneless beef roast and steak cuts trimmed to a fat thickness of no more than three-eighths inch will be consumed almost completely after cooking, and the proportion of such cuts is considered to be the most fundamental measure of carcass "meatiness". One hundred and four steers, 53 Hereford and 51 Angus were slaughtered at Lubbock after feeding 186 days at Lewter Feed Lots, Lubbock. The carcasses were graded and ribeye tracings were made soon after ribbing following a two-day chill. Forty-six left sides were cut in four retail locations at Lubbock, and the remaining 58 left sides were cut in the Texas A&M Meats Laboratory. The chucks at Lubbock were not boned. Sides were selected on an impartial basis without regard to breed to fill the orders for various weights and grades at Lubbock, with 27 Angus and 19 Hereford sides being processed. Multiple and partial correlations were calculated using chilled side weight, average fat thickness over ribeye, fat thickness at rib-plate junction, and ribeye area, as independent variables and the weight of the boneless short loin, loin end, round, rib, and chuck as dependent variables. Chilled side weight contributed most to the resulting multiple correlation coefficients, but fat thickness and ribeye area measurements gave significant increases in most cases. Laboraotry controls on cutting and weighing gave higher correlations. For sum of boneless loin, rib, round, and chuck weights for 58 sides, R=0.93 with partial correlations for chilled carcass wt. 0.86, for fat thickness ribplate —.43, and for ribeye area 0.40. For 34 Herefords, the partial correlation for ribeye area was 0.47 compared to 0.40 for 24 Angus sides.

53. EDIBLE PORTION AND BEEF CARCASS EVALUATION. V. R. Cahill*, L. E. Kunkle, R. F. Plimpton, Jr., and Earle W. Klosterman, *Ohio Agricultural Experiment Station, Columbus.*

Edible portion (EP) and tenderness are two characteristics of beef normally considered to be important. This study was designed to evaluate beef for these characters and to test several indicators which, if reliable, would become useful research tools. Factors checked as predictors of total EP were: weight and size of metacarpal, metatarsal, humerus, and femur; weight of EP in each wholesale cut; EP, separable lean, and *Longissimus dorsi* of 9–11 rib section; and area of Longissimus muscle at 12th intercostal space. To predict trimming fat of the carcass, observations were made of fat thickness at the ribbed surface, weight of fat from each wholesale cut, and trimming of separable fat at 9–11 rib section. Carcasses of 117 steers and heifers from The Ohio Station Hereford cow herd have been evaluated. Results of statistical treatment of these data suggest that edible portion of either the thin cuts or thick cuts or round or chuck are highly indicative of edible portion in the right side. Not so highly correlated are area of *longissimum dorsi* with edible portion, thickness of fat at 12th intercostal space and trimming fat, and marbling score with tenderness score.

54. CARCASS TRAITS OF STILBESTROL TREATED BOARS. V. R. Cahill*, H. S. Teague, L. E. Kunkle, A. L. Moxon, and R. F. Plimpton, Jr., *Ohio Agricultural Experiment Station and Ohio State University, Columbus.*

This phase of experimentation was undertaken to determine the desirability of market-weight boars as meat-type hogs, and the influence that high level stilbestrol implantation might have on the performance and carcass characteristics of these boars. Boars implanted with 48 and 96 mg. of stilbestrol at a live weight of 155 lb. were compared to control boars and barrows. Significant increases in the average daily gain during the treatment period were attributed to the implantation of 96 mg. of stilbestrol. At this level of implant, increased feed efficiency of boars was also observed and the desirable muscling characteristics of boars were retained. Significant differences between all boars, regardless of treatment, and barrows were noted. Boars had decreased dressing percentage, backfat thickness, and percent fat; they showed an increased percent lean cuts, percent primal cuts, and percent ham bone. It was observed that 96 mg. of stilbestrol consistently increased the percent edible portion of the hams for boars. Significant increased weights of adrenal glands and liver were also observed for the 96 mg. group when compared to control boars. No significant differences were found for testicle weight, seminal vesicle weight, or cowpers gland weight.

55. HISTOLOGICAL OBSERVATIONS RELATED TO PORK QUALITY. Z. L. Carpenter*, R. G. Kauffman, R. W. Bray, W. G. Hoekstra, and K. G. Weckel, *University of Wisconsin, Madison.*

Seventy-eight hogs, ranging in age from 4 to 42 months, provided loins which varied in content of intramuscular fat. Histological samples were obtained from the *longissimus dorsi* muscle of the left loin opposite the 7th rib. The right loin provided samples for subsequent taste panel evaluation and objective measurements of quality Microscopic evaluation of the slides prepared from the *longissimus dorsi* provided data describing the fiber diameter, muscle bundle size, connective tissue thickness and fat distribution as well as other subjective measurements. The muscle fibers ranged in maximum diameter from 30 to 86 microns, with the older carcasses having significantly larger fibers. Also with an increase in marbling score there was an increase in maximum fiber diameter. A highly significant correlation of 0.84 was obtained between fiber size and age of the animal. A study of the relationships of fiber size to flavor, tenderness, and juiciness yielded correlation coefficients of —.48, —.48, and 0.20, respectively. The subjective score of total amount of collagenic connective tissue possessed little relationship with the organoleptic rating of flavor, tenderness and juiciness as shown by the correlations of 0.12, 0.05 and 0.17. There was no association of total amount of connective tissue (as subjectively scored) with the age of the animal, however, the thickness of the collagenic connective tissue increased in the older animals. The amount of elastic connective tissue, as seen microscopically, increased with an increase in age of the animals.

56. VARIABILITY OF RIBEYE AREA AND DEGREE OF MARBLING OF BEEF CARCASSES AS INFLUENCED BY METHOD OF RIBBING. J. W. Carpenter* and A. Z. Palmer, *University of Florida, Gainesville.*

Ribeye area and degree of marbling as influenced by method of ribbing was studied using paired sides of 149 beef carcasses. The left side was ribbed in the conventional packing house manner of cutting half-way between the 12th and 13th rib following the contour of the 12th rib. The right side was ribbed cutting across the backbone half-way between the 12th and 13th rib perpendicular to the long axis of the *longissimus dorsi* muscle and striking the 12th rib just beyond the eye muscle. The average ribeye area for the left side was 9.44 sq. in. compared to 8.76 sq. in. for the right sides. Differences between right and left sides were highly significant ($P<.005$).

Apparent degree of marbling differed between sides and the difference was attributed to method of ribbing. Fifty-seven percent of the carcasses had higher marbling scores in the left side compared to nineteen percent of the carcasses indicating more marbling in the right side. Twenty-four percent of the carcasses showed no difference between sides. Difference in apparent degree of marbling between right and left sides were highly significant ($<.005$).

57. RELATION OF ZINC CONTENT TO PORK MUSCLE CHARACTERISTICS. R. G. Cassens*, E. J. Briskey, W. G. Hoekstra and R. W. Bray, *University of Wisconsin, Madison.*

pH values and zinc concentrations were determined 24 hours post-mortem on eight different pork muscles from eight healthy pigs which had received a zinc-supplemented ration (130 ppm total zinc). Zinc concentrations were similarly determined from eight pigs which had received a low-zinc ration (30 ppm) and which showed varying degrees of parakeratosis. Various pork muscles differed widely in zinc content whether expressed per unit dry weight or fat-free dry weight. The *semimembranosus*, from animals receiving the zinc-supplemented diet, contained an average of 63 ppm zinc on the dry weight basis compared to the *serratus ventralis* which contained 223 ppm. Other muscles ranged between these extremes. There was no significant difference in the zinc content of the muscles of the pigs fed the low-zinc diet compared to muscles from those fed the zinc-supplemented diet except for the *serratus ventralis* which contained significantly less zinc in the zinc deficient pigs. The more active muscles contained the largest quantities of zinc. Mean zinc content of a muscle was highly correlated with mean 24-hour pH, but within muscle correlations between zinc and pH were not significant. Additional data on relationships between zinc, myoglobin, pH, expressible water, rate of post-mortem glycolysis and other muscle properties will be presented.

58. EFFECT OF ENDOGENOUS HISTAMINE ON MEAT TENDERNESS. G. E. Clark and A. M. Mullins, *Louisiana State University, Baton Rouge.*

The loose connective tissue from the *longissmus dorsi* taken seven days after slaughter from 32 crossbred steers was used to make natural tissue spreads for the staining of the mast cells. The natural spreads of these tissues were found excellent for demonstrating the abundance of mast cells; however, it is doubtful that this method is reliable for counting purposes because of varying thicknesses of tissue spreads. A subjective method of estimating mast cell numbers as well as the degree of degranulation was used. No significant correlation between these measurements and shear value of the 12th rib was observed, ($r=0.09$). Samples were taken from the diaphram muscle and fixed 15 minutes after slaughter from 40 steer carcasses. No significant correlation was found between the number of mast cells or degree of degranulation and shear value of the 12th rib. Connective tissue spreads were made from the *longissmus dorsi* at seven days after slaughter from five carcasses each of high and low shear value (av. 25.9 and 11.8, respectively). No significant difference in mast cell numbers could be detected. Duplicate 5 gm. samples of the diaphram muscle from 65 crossbred steers were taken 15 minutes after slaughter and frozen in dry ice and acetone. After cooking the 12th rib and determining the shear value, histamine was assayed in 12 diaphram samples each that corresponded to high and low shear values. The amount of histamine per gram of the diaphram tissue tended to increase with the shear value of the 12th rib.

59. RELATIONSHIP OF BEEF TYPE AND BREED TO OFFAL COMPOSITION. J. W. Cole* and C. B. Ramsey, *University of Tennessee, Knoxville.*

Detailed offal information was obtained from 133 steers representing six breeds and five U.S.D.A. grades. The animals were raised under the same environmental conditions and full fed a high concentrate ration to 900 pounds live weight. All animals received a twenty-four hour pre-slaughter shrinkage without feed or water. Highly significant among-breed differences were observed in percentages of rumen, reticulum and esophagus, omasum, abomasum, small and large intestines, ruffle and caul fat, total gastrointestinal tract, hide and viscera. The grade within-breed differences for omasum, abomasum, small and large intestines, total gastrointestinal tract and liver were not statistically significant. Definite trends in percentages of offal components were observed for the types and breeds studied. As the percentage of Brahman breeding increased, the percentage of total viscera decreased. Dairy breeding, with few exceptions, produced cattle with higher offal component percentages than the beef breeds. The percentages of pre-slaughter shrink and cooler shrink were generally larger for the lower grading cattle. Highly significant differences were observed among breeds and among carcass grades when hot carcass weight was divided into the average viscera weight or into viscera weight plus twenty-four hour pre-slaughter shrinkage loss. The among-breed differences for these two variables had a wider range than the among grade percentages. When breed differences are considered the adjustment for live weight, by using a standard viscera percentage, is subject to error. The data show large and significant breed differences in percentages of offal components.

60. RELATIONSHIP OF SPECIFIC GRAVITY TO FAT AND ENERGY CONTENT OF LAMB CARCASSES. R. L. Cowan*, Emery Keck, Jr., J. H. Ziegler, J. L. Watkins and R. C. Miller, *Pennsylvania State University, University Park.*

Twenty lamb carcasses, weighing 17–49 lb. and representing grades from cull to prime, were selected from 45 carcasses from lambs completing a feeding trial. Specific gravity measurements were made on whole carcasses, half carcasses, and dorsal sections cut from the half carcasses containing the ninth, tenth and eleventh ribs. Shank bones were removed from the half carcasses, and the remainder minced in a Schneilkutter. Representative 200 gm. samples were dried under vacuum for analysis. Fat was extracted from the dried samples with $CHCl_3$ in large Soxhlets. Energy values for the fats and fat-free residue were determined in a Bomb Calorimeter. These determinations were used to compute the total energy of the carcasses. Calories per pound of fresh carcasses were correlated with the specific gravity of the whole carcasses, half carcasses, and rib sections.

A highly significant correlation was found to exist ($P<.01$) between calories per pound of fresh carcass and the rib section (—.79), and also for the half carcass (—.70). There was no close correlation of calories per pound of fresh carcass with the specific gravity of the whole carcass. This was probably due in part to air entrapped within the carcass resulting in buoyancy not related to fat content.

61. TECHNIQUE FOR MARBLING BEEF CARCASSES. Ralph M. Durham*, Henry Elliott, and Dale W. Zinn, *Texas Technological College, Lubbock.*

A technique has been developed for injecting liquid edible beef fat into beef carcasses. The technique is as follows: edible tallow is heated to a temperature of 140° F., and pumped directly into the muscles of the carcass at a pressure of 20–30 lb., using a ham pump and a series of perforated needles. This procedure has been successfully used on hot and cold carcasses as well as individual cold wholesale cuts. In carcasses devoid or practically devoid of marbling, such injection of beef fat can be used to stimulate the juiciness associated with naturally occurring marbling. The technique can also be used to standardize the amount of intramuscular fat per pound of meat. Tenderness, as measured by the Warner-Bratzler shear test, was tested between injected and non injected steak pairs. Injected steaks required significantly less pounds cutting pressure. Whether this is due to expansion of the muscle, thereby reducing the number of fibers per core, or to the physical effect of the needles, is not known. No undesirable effects have been noted as regards shelf-life, or flavor. The injected fat gives a slightly pearl-like appearance, but can be distributed in any manner desired.

62. EFFECT OF AGE ON THE GROWTH OF PORCINE MUSCLE. C. E. Elson*, E. A. Kline, W. A. Fuller, and L. N. Hazel, *Iowa State University, Ames.*

Muscle determinations were obtained from five litters of crossbred barrows. The determinations were made at 45-day intervals commencing at 45 days of age with the final determination at 180 days. The muscle fiber area, percent fat, percent water and iodine number of the *longissimum dorsi, psoas major, semimembranosus* and *semitendinosus* muscles were determined. Growth curves of the form $y=K+be^{at}$ and of the form $y=\frac{A}{1+be^{at}}$ were fitted to the determinations on the four muscles. Growth rates varied by muscles and in certain cases by litters. It was inferred that increasing age caused a decrease in the muscular water content and iodine number and an increase in fiber size and fat content. Using the given form, $y=K+be^{at}$ and with a limited number of observations, it was estimated that the *longissimus dorsi* fibers had completed 70% of their growth at 180 days whereas the *psoas major* fibers had completed 50% of their growth and the *semitendinosus* fibers, 99%. At 135 days, the percent of fat was apparently no longer increasing in the *psoas major* where as in the *semimembranosus* and *semitendinosus* the percent of fat was increasing at an increasing rate.

63. CARCASS CHARACTERISTICS OF 100- TO 200-POUND HOGS. J. A. Emerson*, A. M. Pearson, J. A. Hoefer and L. J. Bratzler, *Michigan State University, East Lansing.*

Forty crossbred and 40 Yorkshire hogs were used to study the effect of slaughter weight on the quality and processing properties of pork carcasses. The 80 animals were equally divided into four slaughter weight groups: 100–120 lb.; 130–150 lb.; 160–180 lb.; and 190–210 lb. Each group was balanced as to breeding and sex. The carcasses were dressed packer style, cut and measured using standard techniques. Loin data included area of *longissimus dorsi,* marbling scores, and percent fat, lean and moisture. Specific gravity; percent fat, lean, bone and skin by physical separation; and percent fat, protein and moisture by chemical analysis were obtained on the right ham. The left ham and belly were cured, smoked and evaluated for overall acceptability by taste panel. Roasted loin chops were scored by taste panel for flavor, tenderness and overall acceptability. Warner-Bratzler shear values were obtained on deep fat fried, adjacent chops. Disk colorimetry was employed for the measurement of surface color of the *longissimus dorsi.* Water holding capacity of the *longissimus dorsi* was determined by the filter paper-press method. Consumer acceptance was studied using fresh frozen Boston Butts, loin roasts and loin chops. It was found that, in general, the carcasses of the lightweight hogs compared favorably with those of market weight animals in overall acceptability, quality and processing properties.

64. FACTORS INFLUENCING RELATIVE DEPOSITION OF EXTERNAL FAT AND MARBLING IN BEEF STEERS. S. A. Ewing*, Larry Davis, Wise Burroughs, L. N. Hazel and E. A. Kline, *Iowa State University, Ames.*

The effect of age and feeding regimen on the desirability of beef carcasses were studied using 36 steers 12 months of age divided into three treatments. The steers in treatment 1 received a full feed of corn until the fat cover over the loin reached 0.08 in. per 100 lb. of carcass weight as measured by an ultrasonic device. The steers in treatment 2 were fed

to gain 1.5 lb. daily for 155 days then brought to a full feed of corn and slaughtered when the fat cover was comparable to that observed in treatment 1. The steers in treatment 3 were fed a maintenance ration for 221 days then brought to a full feed of corn and slaughtered when the fat cover was comparable to that of treatments 1 and 2. Physical separation of the rib cut and ether extract values of the *longissimus dorsi* muscle indicated that the carcasses from treatment 1 had significantly less intra-muscular fat ($P<.05$), less separable fat ($P<.005$) and more separable lean ($P<.025$) than those from treatments 2 and 3. In addition shear test values determined on cooked steaks from the short loin were significantly lower ($P<.005$) for carcasses from treatment 1 as compared with those from treatments 2 and 3. Carcass grade and dressing percentage in treatment 1 tended to be lower than in treatments 2 and 3. Correlation coefficients for fat cover and separable fat, fat cover and separable lean, and ether extract of the *longissimus dorsi* muscle and shear values of cooked steaks from the short loin were .44 ($P<.05$), —.29 and .04, respectively.

65. INFLUENCE OF PRESLAUGHTER TREATMENT ON SOME PHYSICAL AND CHEMICAL MUSCLE CHARACTERISTICS OF LAMB. J. C. Forrest*, R. A. Merkel and D. L. Mackintosh, *Kansas State University, Manhattan.*

Thirty-two crossbred lambs were randomly allotted in four lots to study the effect of preslaughter treatment and stress on some carcass characteristics. Treatments were Lot I—Control; Lot II—700 mg. iron sulfate and 70 mg. copper sulfate/lb. creep ration; Lot III—Adrenaline (a) 5 cc. injected subcutaneously 12 hours and again 2 hours before slaughter in four lambs (b) 10 cc. injected 12 hours and again 2 hours preslaughter in four lambs; Lot IV—Exercise (a) four lambs to near exhaustion on a treadmill (b) four lambs to near exhaustion with a sheep dog. All lambs were creep fed and slaughtered at weaning. The carcasses were graded by a government grader with individual factors determining grade being recorded. Maturity as designated by the grader was significantly affected ($P<.001$) by preslaughter stress; however there was no significant difference in days of age at slaughter. The effect of preslaughter treatment was significant ($P<.001$) on pH of the *rectus abdominis* and *intercostal* muscles and significant ($P<.05$) on the pH of the *longissimus dorsi* muscle. Differences in objective color readings of the *rectus abdominis* were highly significant ($P<.01$). Color readings of the *longissimus dorsi* muscle, subjective color scores and firmness of lean were significantly ($P<.05$) affected by treatment. Myoglobin concentration, expressible moisture in the *longissimus dorsi* muscle and firmness of fat were not significantly affected by preslaughter treatment.

66. RELATIONSHIP OF MUSCLE, FAT, BONE AND SOME PHYSICAL MEASUREMENTS TO BEEF CARCASS CUTABILITY. A. Harold Gottsch*, R. A. Merkel and D. L. Mackintosh, *Kansas State University, Manhattan.*

Carcasses of thirty-eight Hereford steers averaging 1046 lb. each at slaughter were studied to investigate beef carcass cutability. The carcasses were graded and a visual appraisal of percent fat, bone, and edible portion recorded. Fat probes of the round, sirloin, shortloin, rib and chuck were made. The right side of each carcass was separated into boneless, retail cuts, trimmed of excess external and seam fat to a maximum of ¼ in. and all weights recorded. The weights were used to calculate percentages of chilled carcass weight for each characteristic. Highly significant correlation coefficients were observed between boneless trimmed lean from the round and chuck with total carcass lean 0.78 and 0.77, respectively. Lean from the round and chuck accounted for 61 and 59%, respectively, of the variation in total carcass lean, while loin eye area accounted for only 18%. A highly significant correlation of —.91 was found between total carcass lean and total carcass fat. The best measure of total fat trim was the highly significant visual estimate of total fat trim, 0.75. The sirloin and round fat probes also were both highly significantly correlated with total fat trim, 0.65. Fat thickness at the 12th rib, whether an av. of three measurements or a single measurement, was highly significantly correlated with total fat trim, 0.57 and 0.58, respectively. Identical multiple correlation coefficients of 0.72 were obtained between fat thickness at the 12th rib (one measurement or an av. of three measurements) with % kidney knob, the five fat probes, and total carcass fat.

67. ESTIMATION OF RIB EYE AREA AND FAT THICKNESS OF BEEF CATTLE WITH ULTRASONICS. H. B. Hedrick, W. E. Meyer*, M. A. Alexander, H. D. Naumann and S. E. Zobrisky, *University of Missouri, Columbia.*

An ultrasonic instrument (Branson Sonoray, Model 5) was used to estimate the area of the rib eye muscle and fat thickness of 202 live cattle. The total number was comprised of four groups of 46, 28, 71 and 57 cattle respectively. Measurements of the rib eye and fat thickness were taken at the 12–13th rib on the left side of the mid-line of groups 1 and 2 and on the left and right sides of groups 3 and 4. Subsequently the cattle were slaughtered and a tracing made of the rib eye and fat cover at the 12–13th rib. The correlations between live animal estimates and carcass for left rib eye area were 0.58, 0.79, 0.89 and 0.75; and for fat thickness 0.53, 0.11, 0.63 and 0.47 for groups 1, 2, 3 and 4 respectively. Correlations between the same variables for the right side of groups 3 and 4 were 0.88 and 0.70 for rib eye area and 0.58 and 0.50 for fat thickness respectively. A comparison of live animal estimates of left vs. right rib eye area of groups 3 and 4 gave correlations of 0.69 and 0.83; and left vs. right of the carcass 0.78 and 0.75.

68. STUDY OF CERTAIN LAMB AND CARCASS QUALITY FACTORS. Richard L. Hiner*, and John W. Thornton, *Meat Quality Laboratory, USDA, Beltsville, Maryland.*

Data on 1138 lambs of the Southdown, Hampshire, Shropshire, and Merino breeds involving one-, two-, and three-breed crosses among these breeds were used to estimate relationships between certain carcass factors and yields of primal cuts. These data

covered a nine year period (1952–60) and consisted of lambs born and raised at the Beltsville, USDA Research Center. Measurable genetic effects were statistically eliminated from this phase of the analysis. Effects studied were birth year, sex, type rearing, and age at slaughter. The lambs were all slaughtered when they reached a final weight of approximately 75 lb. All factors were analyzed on a live (slaughter weight of shorn lamb) and on a chilled carcass weight basis. Year of birth effects were highly significant ($P<.01$) in all instances for all factors. Sex effects were highly significant ($P<.01$) in most instances for carcass measurements and physical separation of the nine-rib rack. Sex effects were not significant for the yields of primal cuts (leg, leg+loin+rib, leg+loin+rib+shoulder) on a carcass weight basis. Partial regressions of slaughter weights and carcass weights with other carcass factors were highly significant but those for carcass weight indicated more accurate relationships. Thirteen carcass quality factors were studied to predict trimmed primal cuts. Of these, eight were statistically significant and accounted for 60 to 70% of the variation. Three of these carcass factors (carcass weight, average body width, and leg circumference) accounted for 56 to 65% of the variation in yield of primal cuts.

69.

70. pH OF CHILLED, AGED AND COOKED PORK AS RELATED TO QUALITY.

R. G. Kauffman*, Z. L. Carpenter, R. W. Bray and W. G. Hoekstra, *University of Wisconsin, Madison.*

The purpose of this investigation was to determine the relationships of chilled, aged and cooked pork muscle acidity with palatability and economical traits. Single pH values were obtained on chilled (24 hours), aged (5–8 days), and cooked loin and ham muscles originating from 439 barrow, gilt, and sow carcasses. The carcasses were selected on the basis of five degrees of loin intramuscular fat and according to either four carcass weight classes (ranging from under 125 lb. to 320 lb.) or five chronological age groups (ranging from 4 to 42 months). The pH values were intercompared and compared to % expressible juice (aged), firmness and color observations, palatability evaluations obtained from a 15-member semi-trained taste panel, and to % commercial curing and cooking shrinkages. Results indicated that increased muscle acidity was related ($P=<.01$) to a higher percentage of expressible juices and was characteristic of pale, soft tissues. Chilled pH values were directly associated ($P=<.01$) to aged and cooked pH values, and there was a positive relationship ($P=<.01$) between the pH of different muscles under identical environments. Darker, drier, firmer muscles exhibiting relatively high pH values shrank less ($P=<.01$) during curing and cooking and were more juicy and tender ($P=<.01$) when compared to pale, soft muscles. Regardless of muscle acidity, the curing process raised all palatability ratings; therefore, it was concluded that the primary importance of pork muscle pH was its association with shrinkage incurred during processing.

71. RELATIONSHIP BETWEEN PHYSICALLY SEPARATED AND CHEMICALLY DETERMINED COMPONENTS OF THE LAMB CARCASS.

Arlin D. Knight* and W. C. Foote, *Utah State University, Logan.*

Ten Rambouillet wether lambs were used to compare physical separation and chemical analysis as methods for estimating carcass tissue components. Physical separation of lean, fat and bone of the leg, rack and one-half carcass was made on the left side and chemical analysis of nitrogen, ether extract, ash and water for the leg, rack and one-half carcass was made on the right side of each carcass. The means and standard deviations of the physical separation percents were 61.4, 2.20; 20.3, 3.36; 18.2, 1.90 for lean, fat and bone of the leg, respectively; 41.2, 3.39; 43.2, 4.03; 15.6, 1.81 for lean, fat and bone of the rack, respectively; 53.0, 3.21; 30.3, 4.19; 16.7, 1.62 for lean, fat and bone of the one-half carcass, respectively. The means and standard deviations for the chemical determinations were 53.5, 2.26; 16.9, 0.89; 24.3, 2.58; 5.2, 0.45 for water, protein (N x 6.25), ether extract and ash of the leg, respectively; 40.3, 1.64; 13.2, 0.85; 42.2, 2.67; 4.5, 0.63 for water, protein, ether extract and ash of the rack, respectively; 47.4, 1.81; 15.3, 0.78; 31.3, 2.70; 4.6, 0.40 for the water, protein, ether extract and ash of the one-half carcass, respectively. Relationship of these two methods of estimating tissue components is indicated by the following simple correlations for the leg, rack and one-half carcass, respectively ($0.63<.05$): 0.76, 0.61, 0.80 for percents of protein and lean; 0.77, 0.90, 0.86 for percents of ether extract and fat; 0.38, 0.54, 0.61 for percents of ash and bone. Low correlations indicate some lack of agreement between the two methods.

72. EFFECT OF PRE-SLAUGHTER TREATMENTS ON THE CHARACTERISTICS OF CERTAIN BEEF MUSCLES.

P. K. Lewis, Jr.*, C. J. Brown, and M. C. Heck, *University of Arkansas, Fayetteville.*

After an 18-hour shrink, 12 good and 12 choice Hereford steers were grouped according to weight and allotted at random to four treatments in a 2 x 2 factorial experiment. Lots 1 and 2 were full fed a practical fattening ration which they had received previously for 120 days, while lots 3 and 4 were fed only 2 lb. of hay per head per day during the week just prior to slaughter. For 24 hours immediately prior to slaughter, lots 2 and 4 were subjected to stress from periodic electrical stimulation while lots 1 and 3 were allowed to rest without feed and water. Fourteen days after slaughter the *longissimus dorsi, psoas major,* and *quadriceps femoris* muscles were sampled for taste panel evaluation, pH determinations, cooking losses, color, and expressible water. Stress significantly increased live shrink and liver weight. Limited feeding significantly decreased fill, live shrink and liver weight. These treatments did not significantly effect yield and cooler shrink. Limited feeding and stress significantly increased the pH of the *psoas major* and *quadriceps femoris* muscles. Stress significantly decreased flavor and aroma scores but increased juiciness scores of the *psoas major.* Stress decreased texture and tenderness scores of the *longissimus dorsi.* All muscles were darkened by stress. Limited feeding decreased the

flavor score of the *psoas major* and *quadriceps femoris* muscles. Limited feeding made the *longissimus dorsi* less tender and darker. Pre-slaughter treatments influenced cooking losses, expressible water, and color of raw and cooked beef muscles.

73. RELATIONSHIP OF LOIN INDICES TO PORK CARCASS MEATINESS. J. B. Marcum* and J. R. Stouffer, *Cornell University, Ithaca, New York.*

Cross-sectional rough loin slices from twelve positions between the tenth and last ribs of 47 hogs were recorded photographically. Loin-eye area, loin-eye depth, loin-eye length, modified fat cover area and modified fat-cover depth were measured directly from a projected image. Modified fat cover area was defined as the area of external fat, covering the *longissimus dorsi* muscle, bounded by two parellel lines, one inch on either side of a line perpendicular to and bisecting the longest axis of the muscle. The relationship of these indices plus a lean-fat value (LFV) and the percentage of lean cuts was investigated. The LFV was defined as the ratio obtained by dividing the *longissimus dorsi* area by the modified fat-cover area. Results of the study showed marked differences in the correlation coefficients between the loin indices and percent lean cuts at the various positions. The positions at the twelfth to fourteenth ribs gave the largest values. The LFV yielded a much higher degree of association with percent lean cuts (range: r=0.706 to 0.757) than did loin-eye area (range: r=0.391 to 0.580). However, modified fat-cover area showed only slightly lower relationships than did the LFV. Fat-cover depth which was much simpler to obtain, proved to be as valuable as any of the other measurements for predicting percent lean cuts. A multiple correlation coefficient of 0.824 at position 12–2 was obtained by associating loin-eye length and fat-cover depth with percent lean cuts.

74. CARCASS EVALUATION OF SWINE SLAUGHTERED AT 170, 190, 210 AND 230 POUNDS. H. C. McCampbell* and D. M. Baird, *Georgia Experiment Station, Experiment.*

Forty-eight purebred Poland China pigs at approx. 37 lb. were allotted on the basis of weight, sex and sire into four replicated lots of six pigs each and fed a corn-soybean type ration in drylot until they weighed 170, 190, 210 and 230 lb. for Lots 1, 2, 3, and 4, respec. As individuals in each lot reached the desired live wt., they were slaughtered. At slaughter the head and leaf fat were removed and the carcasses were chilled 48 hr. before cutting. Carcass weights, measurements and subjective scores for marbling, feathering and color of lean were obtained for each carcass. After cutting, the trimmed primal cuts were weighed as individual pairs for each carcass. Generally as live wt. for the lots increased, A.D.G. decreased (1.56, 1.47, 1.43 & 1.43) and feed required per 100 lb. gain increased (340, 361, 364 & 374). Dressing percent was similar for all lots, approx. 68.6 (based on wt. off test and chilled carcass wt.). Carcass length and average backfat increased as live and carcass wt. increased (Lot 1, 26.2; 1.49; Lot 4, 28.0, 1.92) while loineye area increased only slightly with wt. off test (Lot 1, 4.24; Lot 4, 4.43). The percent lean cuts and primal cuts decreased as market wt. increased (based on wt. off test) Lot 1, 37.52, 45.57; Lot 2, 36.30, 45.19, Lot 3, 36.23, 44.73 & Lot 4, 35.08, 44.66. Analysis of variance results of the ratios of carcass length, av. backfat and loineye area per 100 lb. carcass wt. indicated that Lot 1 was significantly (1% level) higher than Lot 4 for carcass length and loineye area ratios; but that the ratio for av. backfat was not significantly different between lots.

75. VOLATILE CHEMICAL COMPOUNDS IN DRY CURED HAMS. H. W. Ockerman*, T. N. Blumer and H. B. Craig, *North Carolina Agricultural Experiment Station, Raleigh.*

This study was conducted for the purpose of separating and identifying the volatile compounds of dry-cured hams during periods of curing and aging. The volatile compounds were separated from the hams by different techniques (vacuum distillation, steam distillation and sweeping with nitrogen) and were characterized as carbonyl compounds, fatty acids, amines and sulfur compounds. Derivatives were prepared for infra-red spectroscopy and their spectra compared favorably with those of known samples of acetaldehyde, propional dehyde, isobutyraldehyde, methyl ethyl ketone and isovaleral dehyde. Tentative identification for formal dehyde, actone, diacetyl and n-valeral dehyde was made by comparing gas chromatography retention times of unknown compounds with known compounds. The total carbonyl compounds were shown to increase as hams increased in time of aging from 2 to 15 months. Compounds comparatively and tentatively identified by either or both infra-red spectroscopy and gas chromatography techniques were formic, acetic, propionic, butyric and isocaproic acids. Palmitoleic, oleic and linoleic acids analyzed by gas chromatography and expressed as a ratio to the total long chain saturated fatty acids present were found to decrease with the age of the hams. Oleic and linoleic acids had two periods of most rapid reduction—the first during curing and smoking and the second, after nine months of aging. Other compounds found in appreciable or trace amounts were hydrogen sulphide, amonia, methyl amine and monosulfides and/or disulfides. Taste panel results were included.

76. ESTIMATED AND ACTUAL YIELDS OF BONELESS RETAIL CUTS FROM BRAHMAN CROSSBRED CATTLE AND CARCASSES. A. Z. Palmer*, J. W. Carpenter, R. L. Reddish, C. E. Murphey and D. K. Hallett, *University of Florida, Gainesville and U.S.D.A., Agricultural Marketing Service, Washington, D. C.*

One hundred and thirty-eight cattle varying in slaughter weight, breeding and quality grade were used in this study. The purpose of this study was to determine the predictive value of a previously reported estimating equation developed for evaluating cattle and carcasses as to percent of boneless, trimmed retail cuts from the round, loin, rib and chuck. A further purpose was to study the relationship of breeding, slaughter weight, and quality grade with boneless, trimmed retail cut yields. The previously reported estimating equation used in this study and compared with equations developed out of these data was: Percent of boneless, trimmed retail cuts from round, loin, rib and chuck=51.34—

5.78 (fat thickness over ribeye, inches)—.0093 (carcass weight, lb.)—.462 (kidney fat, percent of carcass) 0.740 (area of ribeye, sq. in.). The simple correlation coefficient between on-foot percent estimates and actual percent yields was 0.59 ($P<0.01$); the simple correlation coefficient between on the rail percent estimates and actual percentage yields was 0.76 ($P<0.01$). Correlation coefficients between predicted yield grades and actual yield grades were highly significant. Through regression analysis, the predictive value of on-foot and on-rail estimates is indicated.

77. EFFECT OF 48-HOUR PRE-SLAUGHTER FEEDING ON SLAUGHTER AND CARCASS CHARACTERISTICS OF BARROWS AND GILTS. A. Z. Palmer*, H. D. Wallace and J. W. Carpenter, *University of Florida, Gainesville.*

Two trials involving 103 finished market hogs were conducted to determine the influence of preslaughter feeding treatment on slaughter and carcass characteristics. The feeding of a ration consisting of 60% ground corn and 40% sucrose was compared to the usual procedure of feeding only shelled corn. Feeding periods for the two trials were for the 48 hours and 60 hours prior to slaughter, respectively. The sugar ration increased feed consumption, liver weights, yield of the four lean cuts and improved tenderness and sweetness of the livers. Treatment differences in cooler shrink, pH of the chilled *longissimus dorsi* and tenderness and juiciness of broiled loin chops were not significant. Dressing percent was not affected by the sugar ration although animals fed the ground corn-sugar feed averaged slightly higher percentages.

78. STILBESTROL INFLUENCE ON BOAR PORK ACCEPTANCE. R. F. Plimpton, Jr.*, H. S. Teague, L. E. Kunkle, A. L. Moxon, and V. R. Cahill, *Ohio Agricultural Experiment Station and The Ohio State University, Columbus.*

The relative merits of barrows, boars, and boars implanted with high levels of stilbestrol were examined with specific emphasis on palatability of the pork, muscle characteristics, and estrogenic residues. The implantation of 48 and 96 mg. of stilbestrol at a live weight of 155 lb. significantly reduced "boar-odor" in the *longissimus dorsi* tissue of 200 lb. boars when evaluated by a trained taste panel. A highly significant correlation between the length of treatment period (days on stilbestrol) and reduction of "boar-odor" was observed. The odor scores for the muscle of treated boars were not significantly different than those of barrows. A high correlation between "boar-odor" and "boar-flavor" scores was also noted. The tenderness and juiciness scores of cooked chops were increased by stilbestrol implantation of boars. This treatment also increased the marbling and firmness of the loin eye muscle of these boars and the 96 mg. level of implantation produced loins consistently characterized by abundant marbling, gray-pink color, and firm muscle. A bioassay technique for the determination of residual stilbestrol, utilizing increased uterine weights of mice produced by adding known increment of stilbestrol to both the control tissue and treated tissue, was found to be applicable and reliable for pork tissue. Non-significant estrogen levels of 0.558 ppb. were found in the *longissimus dorsi* tissue of the 96 mg. implanted boars. This technique had a sensitivity of 0.62 ppb.

79. INFLUENCE OF BREED AND STRESS ON PHOSPHORYLASE AND GLYCOLYTIC CHANGES IN PORK MUSCLE. R. N. Sayre*, E. J. Briskey and W. G. Hoekstra, *University of Wisconsin, Madison.*

Twelve pigs from each of the Hampshire, Chester White and Poland China breeds were assigned to four treatments. Lot 1 was fed a 50% sucrose ration for 2 weeks with no preslaughter fast. Lots 2, 3 and 4 were fed a practical swine ration, with Lots 2 and 3 fasted for 56 hr. then fed a 50% sucrose ration for 12 hr. prior to slaughter. Lot 3 was excited and exercised immediately ante-mortem; Lot 4 was fasted 70 hr. prior to slaughter. Total phosphorylase activity and glycogen content were determined in the fresh *longissimus dorsi* muscle. Little or no phosphorylase *a* was found irrespective of breed or treatment. Buffer capacity, consistometer value, pH and color reflectance of the muscle were determined at various intervals post-mortem. Muscles were also subjectively scored for color and texture after a 24 hr. chilling period. Phosphorylase activity was significantly different between breeds but was not associated with treatment or with rate and extent of post-mortem glycolysis. The rate of pH drop and color change was highest in Lot 3 and lowest in Lot 4 ($P<0.05$). Chester White pigs exhibited a lower rate of glycolysis than other breeds ($P<0.05$). Muscle glycogen was significantly affected by both breed and treatment being highest in Hampshires and in Lot 1. Significant relationships between muscle color, pH and consistency will be discussed.

80. RESIDUES OF HEPTACHLOR EPOXIDE IN BODY TISSUES OF BEEF CATTLE. R. S. Temple*, R. B. Myers, L. L. Rusoff, L. D. Newsom, W. P. Barthel, C. Corley, and A. Allsman, *Louisiana State University, Baton Rouge.*

Four mature Angus cows, their crossbred calves, and four crossbred yearling heifers were left on pasture while it was treated, and for 124 days thereafter, for control of fire ants by airplane application of 0.25 lb. of heptachlor per acre. A control group of two Angus cows, their calves and two crossbred yearling heifers were kept on a similar pasture but not treated for fire ant control. Omental fat samples were taken and analyzed for heptachlor epoxide from all the animals initially and at 30-day intervals after treatment from portions of each group. No heptachlor epoxide was found in any of the samples from the control animals. Heptachlor epoxide was found in the samples taken from the animals on treated pasture up to 124 days after treatment at which time the experiment was terminated. No definite differences in amount of residue between ages of animals could be established.

81. RELATIONSHIP BETWEEN CERTAIN WHOLE MUSCLES AND MEASUREMENTS OF PORK CARCASS LEANNESS. D. G. Topel*, R. A. Merkel, D. L. Mackintosh, *Kansas State University, Manhattan.*

Psoas major, semimembranosus, rectus femoris, biceps femoris, and *longissimus dorsi* muscles were

dissected from 51 Hampshire, 12 Duroc, and 26 Crossbred barrow and gilt carcasses. Twenty-four hours post-mortem the carcasses were broken into wholesale cuts and the loin eye area obtained. The five muscles were removed from the right ham and loin, trimmed of adhering tissue and weighed. Volume of the *longissimus dorsi* muscle was determined by displacement of distilled water in a 2-liter graduate cylinder. Partial correlation coefficients, adjusted for differences in side weight, were determined between absolute values of carcass characteristics from the right side of each carcass. Significant ($P<0.01$) correlations between the weight of the *longissimus dorsi* and the weights of *psoas major, semimembranosus, rectus femoris,* and *biceps femoris* muscles were 0.62, 0.50, 0.66, 0.77 respectively. Combined weight of the five muscles was significantly correlated ($P<0.01$) with weight of the four lean cuts (0.75) as was the weight of the *longissimus dorsi* muscle (0.70) and the three ham muscles (0.72). Loin weight (0.76) and loin eye area (0.54) were highly significantly correlated with weight of the four lean cuts. Volume of the *longissimus dorsi* muscle also correlated ($P<0.01$) with weight of the four lean cuts (0.68) and loin eye area (0.82). Loin eye area correlated ($P<0.01$) with the combined weight of the five muscles (0.74) and the three ham muscles (0.53), but did not correlate with weight of the ham (0.08). Carcass length did not correlate with weight of the *longissimus dorsi* muscle (0.01), weight of the ham (0.15), or weight of the four lean cuts (0.21).

82. INFLUENCE OF MARBLING AND ANIMAL AGE ON FACTORS ASSOCIATED WITH BEEF QUALITY. H. J. Tuma*, R. L. Henrickson, and D. F. Stephens, *Oklahoma State University, Stillwater and A.R.S., U.S.D.A.*

The *longissimus dorsi* muscle from the short loin of 24 Hereford steers and females, 18, 42 and 90 months of age, was used for this study. The marbling of each carcass was or closely approached either a "slight amount" or "slightly abundant" level. Tenderness of the *longissimus dorsi* steaks decreased significantly with increasing animal age as measured by the Warner-Bratzler Shear and panel tenderness. The greatest difference in tenderness was observed between the 18 and 42-month age groups. The association between marbling and tenderness varied with animal age. "Slightly abundant" marbling, as compared to a "slight amount" of marbling, did not enhance the tenderness of *longissimus dorsi* steaks from the 18 month old animals. The more tender steaks in the 42 and 90-month age groups, however, were associated with the "slightly abundant" marbling level. The effect of aging 14 days varied with animal age, marbling level and the tenderness measure used. Steaks from the 18-month old animals were influenced little by aging, while those from the 42 and 90-month old animals were scored more tender by the taste panel after aging 14 days. This tenderizing effect due to aging 14 days was nonsignificant as measured by the Warner-Bratzler Shear force values. Taste panel flavor and juiciness scores did not appear to be related to animal age, marbling level or aging 14 days. Marbling in the steaks did not significantly influence any one of the three dimensions of color. A significant increase in pH was noted upon aging 14 days. This increase was observed predominantly in the "slight amount" marbled cattle 42 and 90 months of age.

83. VARIATION IN THE PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE *LONGISSIMUS DORSI* MUSCLE FROM ANIMALS DIFFERING IN AGE. H. J. Tuma, R. L. Henrickson*, G. V. Odell and D. F. Stephens, *Oklahoma State University, Stillwater and A.R.S., U.S.D.A.*

Loins from fifty-six Hereford steers and females, 6, 18, 42 and 90 months of age, were used for this study. The animals possessed a uniform genetic background and received similar nutrition and management treatment. The color of *longissimus dorsi* steaks, as measured by the Photovolt Reflectance Meter, became a darker red with advancing animal age and was a lighter, brighter red upon aging 14 days. Thus, the Munsell value notations decreased with advancing animal age and increased upon aging 14 days. The hue and chroma notations did not show any pattern with regard to animal age. The correlations within each age group between the value notations and panel tenderness, shear, pH, marbling and ether extract were generally low and variable with regard to sign. The pH of *longissimus dorsi* steaks decreased progressively from 5.61 for the 6-month animals to 5.26 for the 90-month animals. Generally an increase in pH was observed from the 2 to 14-day aging period. Moisture content differed little among the 18, 42, and 90-month old animals, but was higher for the 6-month old calves. The ash and protein content were not significantly different for age groups. Panel tenderness and shear force values indicated that 6-month old calves were less tender at 2 days postmortem than the 18-month old animals, however, upon aging 14 days, they were more tender. Panel flavor and juiciness scores were influenced only slightly by animal age or aging. Simple correlation coefficients revealed that taste panel scores and Warner-Bratzler shear values were more closely related for the 6 and 18-month old cattle than for the 42 and 90-month old animals.

84. EFFECT OF HIGH ROUGHAGE RATIONS ON LAMB CARCASS FIRMNESS. W. R. Usborne*, B. C. Breidenstein, J. H. Sokolowski, U. S. Garrigus, and E. E. Hatfield, *University of Illinois, Urbana.*

Forty-eight lambs were used in a 2 x 3 factorial experiment consisting of two forms of ration (meal and pelleted) and three levels of alfalfa and corn (30% and 55%, 50% and 35%, 70% and 15% respectively). Each diet consisted of ten percent soybean meal and five percent molasses. The subcutaneous fat of these carcasses was subjectively evaluated and then samples taken for chemical analyses. Percent ether extract and crude protein were calculated from a composite sample of the left side of the carcass. There were no significant differences due to subjective evaluation, iodine number, and melting point of the subcutaneous fat; carcass grade; and, average daily gain. The high roughage ration (70%) carcasses showed significantly higher crude protein ($P<.01$) and lower ether extract ($P<.05$). The lambs fed the high concentrate rations had a significantly higher dressing percent. The lambs fed the pelleted ration had a significantly higher daily gain ($P<.01$), lower crude protein ($P<.05$), and higher ether extract ($P<.05$).

85. EFFECT OF SEX ON ORGANOLEPTIC QUALITIES OF YOUNG LAMB. W. R. Usborne*, J. H. Sokolowski, B. C. Breidenstein, B. B. Doane, E. E. Hatfield, and U. S. Garrigus, *University of Illinois, Urbana.*

Off flavors and odors of lamb have been attributed to sex characteristics. This study was designed to determine if such sex characteristics could be detected in spring lambs using standard organoleptic techniques. Thirty-six crossbred lambs consisting of selected full and half-brother, ram and wether pairs were fed rations consisting of either regular or high oil corn until they reached market weight (90 to 120 days of age). A 1½–2 lb. sirloin roast was saved from the right leg for taste panel analysis. Each roast was cooked in a separate covered pan to an internal temperature of 180° F. All of the external fat was trimmed off after roasting. Uniform unseasoned lamb samples were analyzed by a trained taste panel. The organoleptic qualities, aroma, flavor, and tenderness, were evaluated on a ten point scoring system. Under these conditions lamb of this age showed no significant differences among the organoleptic characteristics evaluated due to sex or ration treatment.

86. FURTHER STUDIES ON SEX ODOR IN PORK. L. D. Williams*, A. M. Pearson and N. B. Webb, *Michigan State University, East Lansing.*

The incidence of sex odor in pork was studied using fat samples taken from the flank area of boars, barrows and gilts. Evaluation of the intensity of sex odor was made by an organoleptic panel selected for their ability to detect sex odor in pork. Approximately 12 gm. of fat was heated to about 200° C. in a 250 ml. Erlenmeyer flask until the odor of the fat became apparent. The samples were then scored according to the degree or intensity of odor, as either none, slight or strong. No differences were observed ($P<.01$) in the ability of the panel members to detect sex odor. Therefore, a mean was calculated from the three obsevations on each animal. Approximately 25% of all boars were rated as having a strong sex odor, 42% as having a slight sex odor while the remaining 33% showed none. In 150–210 lb. market barrows, no sex odor was found, and less than 1% occurrence was observed in 175–235 lb. market gilts. It was found that boar meat having a strong sex odor could be incorporated into some of the more highly spiced comminuted meats without detection. This was found to be successful only in meats that were consumed cold. If the comminuted meats containing sex odor were heated, the volatile substance(s) responsible for the odor was/were liberated and could be readily detected by the panel.

87. EVALUATION OF U.S.D.A. BEEF GRADING METHODS. Dale W. Zinn*, Henry Elliott, Dale Burnett and Ralph M. Durham, *Texas Technological College, Lubbock.*

Forty-eight Hereford and 48 Angus steer calves were divided into three treatment groups and fed for 185 days on a high silage ration of either corn, red-top cane or sart silages. One half of the steers on each treatment received a 12 mg. stilbestrol implant at the beginning of the feeding period. Slaughter data, U.S.D.A. grades, cutout and tenderness studies were obtained under the same environmental conditions within a given "work" day. The average weight of the 96 cattle at time of slaughter was 920 lb., with an average carcass grade of high good. The gross simple correlation coefficients calculated were: carcass conformation score—cutout (—.50), dual grading estimate—cutout (—.46), loin-eye area —cutout (—.61), fat thickness over 12th rib—cutout (—.54), marbling score—carcass grade (0.89), and marbling score-pounds of shear (—.08). These coefficients show the cattle scored higher in conformation yield lower cutouts, as do the fatter cattle. The coefficient of marbling to tenderness suggests that, in these cattle, 99% of the variation in tenderness is due to factors other than marbling; while the coefficients of marbling to grade indicates that about 80% of the variation in grade is determined by marbling.

88. HIGH FREQUENCY SOUND ESTIMATES OF MEATINESS IN SWINE. S. E. Zobrisky, Wm. G. Moody*, B. N. Day and H. D. Naumann, *University of Missouri, Columbia.*

The relationship between High Frequency Sound (Branson Model 5) measurements and conventional carcass indices of meatiness were studied from 237 Poland China hogs. The data were analyzed on a sex and live weight basis. The correlations between the four lean cuts, actual and also High Frequency Sound estimated area of the *longissimus dorsi* muscle were significant ($P<0.01$) within sex and weight groups. Likewise the correlations between total carcass trim fat and backfat thickness as measured on the carcass and estimated by High Frequency Sound were significant ($P<0.01$). The multiple correlations of backfat thickness and *longissimus dorsi* area as estimated by High Frequency Sound with the four lean cuts and also the total trim fat were highly significant. ($P<0.001$). The results were comparable to those obtained by employing conventional carcass measurements. These results indicate that the High Frequency Sound technique can be employed on live hogs to reliably estimate backfat thickness, *longissimus dorsi* area, the yield of total trim fat and the yield of the four lean cuts.

89. LIVE ANIMAL AND CARCASS INDICES OF LAMB COMPOSITION. S. E. Zobrisky*, Wm. G. Moody, C. V. Ross, H. D. Naumann, and H. B. Hedrick, *University of Missouri, Columbia.*

Live animal and carcass data from 70 lambs were analyzed to determine the relationship between various indices of meatiness. The estimated High Frequency Sound (Branson Model 5) loin eye area was significantly correlated with the actual loin eye area and weight of primal cuts. Loin eye area was correlated 0.72 and 0.80 with depth and length x depth of loin eye. The weight of the metatarsal bones was correlated ($P<0.001$) with the weight of leg. Similarly, the weight of the leg was correlated ($P<0.001$) with the total weight of the primal cuts. A lamb chop 1.5 inches in thickness obtained posterior to the thirteenth rib was correlated 0.56 and 0.67 with the weight of the lamb leg and primal cuts respectively. Fat thickness over the thirteenth rib was significantly correlated to the yield of shoulder. Live animal and/or carcass grades were not strongly associated with the carcass cut out data. However, conformation, maturity, fat streaking, and feathering

scores were found to be interrelated. Of these scores, conformation and maturity were most highly associated with composition indices.

90. MEATINESS OF SWINE AS INFLUENCED BY BREED, SEASON AND SEX. S. E. Zobrisky*, Wm. G. Moody, L. F. Tribble, and H. D. Naumann, *University of Missouri, Columbia.*

Data from 96 hogs, equally divided into two seasons, two-breeds and three sexes by litters, were analyzed to determine differences in growth and carcass characteristics. Boar carcasses in both breeds contained a greater ($P<0.01$) yield of lean and had larger loin eye areas than littermate barrows and gilts. Similarly, the gilt carcasses of both breeds contained a greater ($P<0.05$) yield of lean and had larger loin eye areas than littermate barrows. Differences between the two breeds in yield of trimmed carcass fat were not significant. However, the barrows of both breeds contained significantly more ($P<0.01$) fat than littermate boars and gilts. The hogs slaughtered in the summer were, however, fatter ($P<0.01$) than hogs slaughtered in the winter. Birth weight, carcass weight, dressing percent and backfat thickness were not significantly different. However, these variables were significantly greater ($P<0.01$) for the hogs slaughtered in the winter than in the summer. Season apparently had no influence on separable ham lean. However, hams from boars and gilts contained more ($P<0.01$) lean than hams from littermate barrows. Conversely, the hams from the barrows contained more ($P<0.01$) fat than hams from littermates. These results clearly indicate that breed, season and sex influenec meatiness of swine.

91. EFFECT OF SLAUGHTER WEIGHT ON COMPOSITION AND EFFICIENCY OF SWINE. L. B. Allen*, H. R. Thomas, P. P. Graham, R. F. Kelly, and C. C. Brooks, *Virginia Agricultural Experiment Station, Blacksburg.*

Fifty-six pigs were slaughtered at weights of 50, 100, 150, or 200 lb. to determine carcass composition. Complete feed records were kept to determine efficiency. The feed used per pound of pig (sow and pig) was 3.58, 3.05, 3.19 and 3.44 lb., respectively, to 50, 100, 150, and 200 lb. Lean meat increased at a decreasing rate as slaughter weight increased. From 150 to 200 lb. the following carcass increases occurred: *longissimus dorsi* muscle 0.7 inch in area and 267 gm. in weight, separatable lean 15.0 lb. and total edible protein 4.2 lb. This represents a 16.7% protein conversion feed to meat during this period as compared to a 19.6% conversion up to 150 lb. Backfat, trim fat, total separated fat and ether extract increased at an increasing rate as slaughter weight increased. These changes being 1.00 to 1.27 in., 8.3 to 15.9 lb., 27.2 to 45.5 lb., and 31.9 to 54.7 lb., respectively, from 150 to 200 lb. slaughter weights. Energy conversion, feed to muscle and fat energy from 150 to 200 lb., was 30.8% as compared to 25.3% up to 150 lb. Trimmed lean cut and primal cut yield from the carcass decreased as slaughter weight increased. Lean cut yield from live weight increased to 150 lb. and then decreased to 200 lb. while primal cut yield continued to increase up to 200 lb. weight. Live weight yield of trimmed ham, picnic, and butt was constant. The loin yield increased to 150 lb. then dropped off while the belly yield increased to 200 lb.

92. COMPARISON OF MILO, CORN AND BARLEY FOR GROWING AND FINISHING HOGS. Stanley E. Anderson and Richard Hanby, *Texas Technological College, Lubbock.*

For each acre of corn harvested in North Central and West Texas in 1960, there were 25 acres of barley and 100 acres of milo. Since milo is being exported to foreign countries that have traditionally fed barley to hogs, an experiment was set up to obtain additional information that may help domestic and foreign markets for milo in swine rations. Eight lots of 10-week old pigs were randomly allotted by breed, sex and weight into four replicated ration groups as follows: 1. Pelleted ground corn, 2. Pelleted ground barley, 3. Pelleted ground milo, 4. Cracked milo. A 37% protein supplement was added to all rations, with protein content thereby determined by protein content of the grain. The pigs were slaughtered as they approached 200 lb. In general, the results indicated milo and corn equal in producing pork, both exceeding barley, with more economical gains for hogs fed milo or corn when prices are similar. There was an advantage for pelleted milo vs. loose milo of 0.541 lb. less feed to produce a pound of gain, and a saving of 0.13¢ per 100 lb. of pork produced. Although the carcass composition seems more desirable for the hogs fed barley because they were leaner, an analysis of variance did not show this difference to be significant.

93. EFFECTS OF FEEDING DRYLAND AND IRRIGATED SORGHUM GRAIN FOR GROWING AND FINISHING SWINE. Stanley E. Anderson, Henry Urban, Robert Albin and Richard Hamby, *Texas Technological College, Lubbock.*

Two varieties of Sorghum grain (Red Bine 66 and Hybrid 601), each grown under dryland and irrigated conditions, were fed to determine their effects in growing and finishing swine. Eight lots of six pigs each were fed four rations with each ration replicated once. The grain sorghum in all lots was mixed 4:1 with a 32.6% protein supplement. Because of the different percentages of protein in each kind of grain sorghum, each ration varied in percentage of protein. Rations of dryland grain averaged 14.7% protein while the irrigated grain rations averaged 12.95%. Thirty-four more pounds of feed was required to produce one hundred pounds of gain with irrigated milo (363 lb.) than with dryland milo (329 lb.). Daily gain, inches of back fat, loin muscle, and percent lean cuts produced by dryland and irrigated grain sorghum varied 163–167 lb., 1.26–1.31 in., 4.03–3.98 sq. in., and 55.8–55.7% respectively. These differences are small and not statistically significant. However, the data suggest an advantage in feed conversion for dryland grain sorghum.

94. INFLUENCE OF PROTEIN DEFICIENCY ON THE UTILIZATION OF VITAMIN A AND CAROTENE. T. A. Anderson*, Farris Hubbert, Jr., C. B. Roubicek and R. E. Taylor, *University of Arizona, Tucson.*

Seventeen vitamin A-deficient sheep were fed either a protein deficient (5.9% C. P.) or a protein adequate (10.4% C. P.) ration. At the end of an 8-week protein depletion period all sheep were biopsied for

liver samples and allotted to the following treatments: control, daily intraruminal injections of 0.1 mg. vitamin A acetate/kg. body weight, and daily intraruminal injections of 0.2 mg. B carotene/kg. body weight. All sheep were sacrificed at the completion of a 4-week injection period to obtain adrenal, thyroid and total liver weights. Significant depressions in serum albumin, albumin: globulin ratio, plasma vitamin A and body weight were noted in the protein deficient sheep at the end of the protein depletion period and also at the termination of the 4-week injection period. Vitamin A, when injected intraruminally and expressed in terms of total liver storage, was stored more than twice as efficiently by sheep fed the protein adequate ration (26.7 mg.) as compared with the protein deficient sheep (11.9 mg.). Level of protein was without any appreciable influence on carotene conversion to vitamin A. The vitamin A injections (0.1 mg./kg. body wt.), measured by total hepatic vitamin A, were approximately 9 times more effective than the carotene injections (0.2 mg./kg. body wt.) in the protein deficient sheep and more than 18 times as effective in the sheep receiving adequate protein. Adrenal weights, expressed as a % of body weight, were significantly lighter in the protein deficient sheep ($P<0.01$). The control animals showed significantly lighter adrenal and thyroid weights ($P<0.01$), regardless of the level of protein fed.

95. HIGH ROUGHAGE VS. HIGH ENERGY STEER FATTENING RATIONS. W. B. Anthony, R. R. Harris* and J. G. Starling, *Auburn University Agricultural Experiment Station, Auburn, Alabama.*

High roughage cattle fattening rations are used in Alabama because concentrates are relatively scarce. Previous work showed high roughage mixtures to be superior to low roughage mixtures (J. A. S. 19: 1306, 1960). Present work evaluated a high energy (HE) mixture and several high roughage (HR) mixtures. The (HE) consisting of corn meal, protein supplement, molasses, and mineral was inferior to (HR) consisting of either 30% of hay, cottonseed hulls or peanut hulls, and ground snapped corn, protein supplement, molasses, and mineral. During a 180-day fattening period, yearling steers made an average daily gain of 2.45 lb., on the (HR), whereas comparable gain on the (HE) was 2.11 lb. (significantly lower). Feed per cwt. of gain was significantly lower for the (HE), 775 vs. 1005 lb. Slaughter grades of test groups were essentially equal. Economic conditions favored feeding the (HR). At the end of the feeding period plasma and liver carotene of the cattle were depleted. Plasma vitamin A averaged 17.35 mcg./100 ml. and liver vitamin A averaged 21.06 mcg./gm. No outward symptoms of vitamin A deficiency were observable. Nutrient balance data for the several mixtures were obtained and will be reported. These data substantiate earlier reports from this station that the greatest "Reach" lies in developing improved high roughage rations for finishing cattle.

96. URINE pH AND THE FORMATION OF UROLITHS IN CATTLE. L. M. Bezeau*, C. B. Bailey, and S. B. Slen, *Canada Agriculture Research Station, Lethbridge, Alberta.*

Two groups of 20 Hereford range cows were carried through pregnancy to weaning on a ration of native prairie hay or grass (depending on the season) and sodium chloride containing 100 I.U. of vitamin A per gram of salt, fed *ad libitum*. After weaning the male calves were maintained on the same ration to one year of age. One group received, in addition, dried molasses-beet pulp and potassium bicarbonate. Calves were slaughtered at birth, weaning, and one year of age and examined for the presence of uroliths. In the winter when hay was fed, the pregnant cows, and later the calves, in the beet pulp group produced an alkaline urine while the urine of the control group was acid. During the summer on range the urine of both groups was alkaline. Three calves from each group were slaughtered at birth. Uroliths were present in all of them. At weaning two calves from each group were slaughtered. Uroliths were found in all calves but the average weight of uroliths was 4.5 times greater in the beet pulp group (168 mg.) than in the control group (37 mg.). At one year of age the figures were 778 mg. and 189 mg. respectively. It is concluded that the formation of urinary calculi is not a simple function of the pH of the urine.

97. EFFECTS OF STILBESTROL AND CHLORTETRACYCLINE ON PERFORMANCE AND CARCASS CHARACTERISTICS OF GRAZING STEERS SELF-FED CORN WITH FAT. E. R. Barrick*, M. B. Wise, R. L. McGuire and T. N. Blumer, *North Carolina Agricultural Experiment Station, Raleigh.*

The effects of diethylstilbestrol implants on the performance and carcass characteristics of grazing steers self-fed corn with 10% added animal fat have been studied in five trials conducted in different years. The effects of adding chlortetracycline to the corn-fat mixture to provide a daily intake of 70 to 100 mg. was studied in three of these trials. Yearling steers weighing 600 to 700 lb. were implanted with 24 mg. of diethylstilbestrol at the beginning of the grazing period. Ladino clover-grass pastures were used and the grazing periods varied from 125 to 194 days. The average daily gain of 91 steers implanted with diethylstilbestrol in the five trials was 2.58 lb. This was 22% greater than gains made by the non-implanted steers. The effects of the use of diethlstilbestrol implants on carcass characteristics were not marked and were not consistent from trial to trial. When the animals were slaughtered after the same length of time on experiment, there were no significant differences in the carcasses as measured by carcass grade, separable fat lean and bone of the rib section, rind thickness, fat deposits per sq. in. of ribeye and percent ether extract in the ribeye muscle. Chlortetracycline resulted in some increase in daily gain and a slightly higher degree of finish as measured by slaughter and carcass grades, percent of fat in the rib section, rind thickness and objectively measured marbling. Although these differences were small, they were apparent in all trials.

98. RELATIONSHIP BETWEEN MICROBIAL PROTEIN SYNTHESIS AND THE ADAPTATION RESPONSE. K. M. Barth*, G. A. McLaren and G. C. Anderson, *West Virginia University, Morgantown.*

Previous studies at the West Virginia Station have shown that the utilization of non-protein nitrogen by the lamb improves with time. This is referred to as

the "adaptation response". The purpose of the present work was to determine whether changes in the microbial pouulation of the rumen contributed to this adaptation response. *In vitro* protein synthesis was used as the criterion to determine if the protein synthesizing capacity of the microorganisms would increase with time. Two wether sheep fitted with permanent rumen fistulae were maintained for 49 days on a semi-purified diet in which 87% of the total N was supplied by urea. Rumen liquor samples were obtained at weekly intervals, and 5 ml. aliquots were incubated for 24 hours in 30 ml. screw-cap test tubes containing cellobiose, glucose, urea and McDougall's nutrient solution. Protein was precipitated with trichloroacetic acid and digested in a micro Kjeldahl apparatus. Ammonia in the digests was nesslerized and measured spectrophotometrically. *In vitro* protein synthesis was not increased as a function of time. This would indicate that a change in the rumen microorganisms is not the cause of the adaptation response to urea-nitrogen. During the course of the *in vitro* studies five successive 7-day nitrogen metabolism trials were conducted. The utilization of absorbed nitrogen increased from 36% to 51% from the first to the fifth trials. This adaptation response was greater than in previous work with lambs fed lower percents of urea.

99. LEVELS OF SUPPLEMENTAL VITAMIN A FOR FATTENING BEEF CATTLE. W. M. Beeson, T. W. Perry*, W. H. Smith and M. T. Mohler, *Purdue University, Lafayette, Indiana.*

Seventy-two steer calves were divided into 12 lots of six each in a 2 x 6 factorial in which ½ of the lots received no alfalfa in their ration whereas the other six lots received 10% of sun cured alfalfa meal, replacing 10% of ground corn cobs. Levels of 0, 10,000; 20,000; 30,000; 40,000; or 50,000 I. U. of vitamin A were fed as vitamin A palmitate. A free choice fattening ration of eight parts ground ear corn to one part soybean oil meal (plus bonemeal and cobalt salt) was fed. In the six lots fed no sun cured alfalfa meal, daily gains ranged from 1.88 lb. in the control lot to 2.48 lb. for those fed 20,000 I. U. of vitamin A per day. For the lots receiving 10% alfalfa meal, gains ranged from 2.23 lb. in the control lot to 2.59 lb. in the 20,000 I. U. lot, with no advantage for higher levels. The 10,000 I. U. level was intermediate in both cases. Plasma vitamin A levels reached a plateau at the 30,000 I. U. level in both the alfalfa-supplemented lots (64 mcg. %) and those not fed alfalfa (53 mcg. %). Controls fed no supplemental vitamin A, either with or without alfalfa showed a similar plasma vitamin A level (16 vs. 11 mcg. %). Plasma carotene levels were erratic; but in general, tended to be lower as the level of supplemental vitamin A was increased. Levels of plasma carotene ranged from 32 to 59 mcg. % among the 12 treatments.

100. TEST OF NRC NUTRIENT REQUIREMENTS FOR SWINE BY LINEAR PROGRAMMING. J. M. Bell*, *University of Saskatchewan, Saskatoon, Saskatchewan, Canada.*

Grower rations were computed for 80 weanling pigs to compare minimum nutrient levels, with and without antibiotic supplement, with rations containing 15% margin of safety on protein, calcium, phosphorus, lysine, methionine, tryptophan, riboflavin, pantothenic acid, vitamins A, D and B_{12}. At 100 lb. weight, pigs were re-allotted by factorial design to finisher rations in order to test combinations of low and high levels (NRC bacon *vs* meat type rations) of protein and energy in linear-programmed rations. Records of individual feed intakes, gains, protein and energy digestibility and carcass quality were obtained. Antibiotics failed to affect grower gains or feed efficiency but growing pigs fed the higher nutrient levels gained 30% faster. It is concluded that lysine, tryptophan or protein levels, rather than vitamins or minerals, were among the factors limiting growth in pigs fed NRC requirement levels of nutrients. In finishing rations energy levels had little effect on any criterion but the use of 16% vs 13% protein resulted in 11% more 'eye-of-lean'.

101. LIMITING AMINO ACIDS OF SOYBEAN AND CORN-SOYBEAN PROTEINS. T. H. Berry*, D. E. Becker and A. H. Jensen, *University of Illinois, Urbana.*

Seven factorial experiments, using individually fed animals, were conducted to determine the limiting amino acids in soybean and corn-soybean proteins. Pigs fed an 8% protein, glucose-soybean meal diet supplemented with 0.2% DL-methionine had a significantly ($P<.01$) greater rate of gain than did the non-supplemented group. The same diet supplemented with 0.2% DL-methionine + 0.078% DL-threonine supported a rate of gain greater ($P<.10$) than the diet supplemented with methionine alone. Rats fed a diet containing 7% soybean meal protein gained significantly ($P<.01$) more when 0.19% DL-methionine was added. In the presence of this amount of methionine, 0.38% supplemental DL-threonine further increased gains ($P<.01$). Supplementary L-lysine, L-valine, L-histidine and L-isoleucine had no effect. Pigs fed a 12% protein, corn-soybean meal diet supplemented with 0.05%, 0.10% or 0.15% DL-methionine with and without 0.1% supplemental L-lysine gained fastest ($P<.01$) at the lowest level of methionine supplementation. However, this gain was less ($P<.01$) than that made by pigs fed 16% protein. In a subsequent trial, the 12% protein diet was supplemented with 0.25% and 0.50% L-lysine with and without 0.10% DL-methionine. The lower level of lysine alone improved gains slightly, whereas the higher level of lysine alone depressed gains slightly. Pigs fed the higher (0.50%) level in the presence of methionine produced gains ($P<.05$) equal to that of pigs fed 16% protein. With rats fed a 7% protein, corn-soybean meal diet, 0.15% supplemental DL-methionine depressed gains ($P<.01$) and .06% supplemental L-tryptophan improved gains. Supplemental L-lysine had no effect.

102. EFFECT OF DIETARY NITRATE ON UREA UTILIZATION *IN VITRO* AND *IN VIVO*. R. A. Bloomfield, G. B. Garner, C. Welsch and M. E. Muhrer*, *University of Missouri, Columbia.*

The effect of KNO_3 on urea utilization (U.U.) *in vitro* was determined by incubating 20 ml. of sheep rumen fluid (R.F.) with 34 mg. urea (3.4% of diet), 1 gm. glucose, buffer, and mineral solution for a total volume of 35 ml. The amount of amonia and urea nitrogen present after 18 hours was used

as the criteria for U.U. The addition of KNO_3 to the flasks at levels of 5, 10, 15, and 20 mg. decreased U.U. by 19.6, 39.8, 65.7, and 85.8% respectively. Comparable levels of KNO_3 with steer R.F. decreased utilization by 17.2, 20.6, 56.8, and 75.8%. These values could be lowered when the R.F. was drawn from the animal just after feeding. The NO_2 ion appeared to be more toxic than the NO_3 ion. Levels of KNO_2 equivalent to 0.07, 0.18, 0.66, 0.74, and 1.0% of the diet decreased U.U. by 4.3, 12.4, 33.4, 38.3, and 53.0% respectively. Levels of KNO_3 above 3.0% were necessary before detectable amounts of NO_2 were present after 18 hours. The *in vivo* effect of KNO_3 on U.U. was determined by placing 6 wethers on a ration of corn cobs, starch, cerelose, molasses, minerals and 3.2% urea. Three animals received 1.1% KCl and the other group received 1.5% KNO_3 for 10 days before the 6-day collection period. The KCl group had a positive nitrogen balance of 1.62 gm./day and the KNO_3 group had a nitrogen balance of 0.53 gm./day.

103. EFFECT OF SIXTEEN TIMES A DAY FEEDING ON UREA UTILIZATION. R. A. Bloomfield*, C. Welsch, G. B. Garner, and M. E. Muhrer, *University of Missouri, Columbia.*

Our previous work has shown that urea hydrolysis proceeded at a rate four times faster than the corresponding uptake of amonia nitrogen (J. Animal Sci. 19:1248). This resulted in a loss of nitrogen to the rumen bacterial population for protein synthesis. An experiment was initiated to determine the effect of more frequent feeding of less urea to keep rumen NPN at a minimum. Six western wethers were fed a ration of corn cobs, starch, molasses, cerelose, corn oil, minerals and 3.2% urea. The trial was divided into three phases; (I) six animals fed twice daily (II) three of these animals fed 16 times a day and (III) the same three animals fed twice daily in a reversal designed experiment. Nitrogen balance showed urinary excretion of (I) 6.66, (II) 5.63, and (III) 7.13 gm. N/day and fecal excretion of (I) 3.43, (II) 4.30, and (III) 3.63 gm. N/day for a nitrogen balance of (I) 1.16, (II) 1.22, and (III) 0.49 gm. N/day. The nitrogen balance data alone does not reflect the decrease in urinary nitrogen expected of an increase in urea utilization. Blood urea values of (I) 10.26, (II) 5.68, and (III) 10.92 mg. urea N/100 ml. indicate an increase in urea utilization in phase II. Whole blood albumin values of (II) increased about 30% over (I) indicating an increased urea utilization. Feeding 16 times a day appeared to increase urea utilization.

104. LIPID METABOLISM STUDIES WITH CATTLE. V. R. Bohman*, M. A. Wade, C. R. Torell and A. L. Lesperance, *University of Nevada, Reno.*

Seventy-two weanling Hereford steers were allotted to treatments in a 2 x 2 x 3 factorially designed experiment during a 2-year period. The experimental treatments were two levels of animal fat, 0 and 0.5 lb. daily, two levels of starch as barley, 0 and 1.1 lb. daily, and three levels of protein as alfalfa pellets, 0, 3 and 6 lb. daily. The basal ration was native grass hay and a mineral mix *ad lib.* All animals were individually fed for an experimental period of 151 days. On the low level of protein each energy supplement increased the rate of gain but the effect was not additive. On the high protein level, only the combination of barley and fat increased the rate of gain above the all roughage rations. This interaction was statistically significant. Both total feed consumption and consumption of the basal ration were significantly modified by the dietary treatments. Dietary fat increased the level of plasma carotene, plasma vitamin A, plasma cholesterol, plasma lipid phosphorus, Allen fat, liver cholesterol, and liver carotene. Fat had no effect on the hematocrit or liver vitamin A. Dietary protein decreased plasma carotene, plasma cholesterol, plasma lipid phosphorus, Allen fat and liver vitamin A. It had no effect on the other tissue constituents. The carotene content of the alfalfa and grass hay was approximately equal.

105. FACTORS AFFECTING THE NITRATE CONTENT OF FORAGES. G. W. Breniman*, A. L. Neumann, G. S. Smith, and J. E. Zimmerman, *University of Illinois, Urbana.*

The nitrate contents of corn plant components from unfertilized and fertilized (10 tons manure plus 300 lb. NH_4NO_3 per acre) fields were compared. Average nitrate contents (percent KNO_3 equivalent, dry basis) of weekly samples (August 16-September 13, 1960) from the unfertilized and fertilized fields, respectively, were: leaves plus sheath, 0.11, 0.29; internodes, 0.36, 2.13; and, ears plus husk, 0.15, 0.17. Samples were taken from the fertilized field at three hour intervals from 5:00 a.m. to 5:00 p.m. (standard time) on a cloudy day (September 9, 1960) and on a sunny day (September 11, 1960). Average nitrate contents of plant components on the cloudy day versus sunny days were: leaves, 0.16, 0.19; internodes, 0.92, 1.27; and, ears, 0.10, 0.12% KNO_3 equivalent, dry basis. The nitrate content of ears remained rather constant throughout each day, but both leaves and internodes varied with time of day as well as cloud cover. Observation of higher nitrate contents in leaves and internodes on the sunny day may have been due to higher temperature and lower soil moisture on the sunny day. At ensiling time nitrate contents of ear components of samples from unfertilized versus fertilized fields were: cob, 0.025, 0.022; grain, 0.139, 0.183; and, husk, 0.071, 0.063% KNO_3 equivalent, dry basis. Nitrate contents were compared in samples of ungrazed grass growing on cattle droppings and of grazed grass growing nearby. Average values for grazed versus ungrazed samples were: (May 4) 0.37, 2.01; (May 18) 0.41, 1.82; and, (June 1) 0.34, 0.59, % KNO_3 equivalent, dry basis.

106. EFFECT OF DIETARY LYSINE LEVEL ON CERTAIN BLOOD PHENOMENA AND TOLERANCE OF SWINE. C. C. Brooks*, J. W. Davis, K. G. Libke, H. R. Thomas, and P. E. Vipperman, *Virginia Agricultural Experiment Station, Blacksburg.*

Five lots of six pigs each were fed a corn-peanut meal ration supplemented with vitamins, minerals, and antibiotic. These rations were supplemented with 0.0, 0.3, 0.6, 0.9, and 1.2 percent L-lysine (HCl), respectively. A sixth lot received a corn-soy ration. Protein levels were lowered from 16% to 14% to 12% at 75 and 150 pounds, respectively. Lysine supplement was lowered at a corresponding level. Blood samples were taken at 0, 43 and 70 days and at slaughter. The pattern at 70 days was typi-

cal, showing a sedimentation rate decrease from 21 in the basal to 10 mm./hr. in the 0.6% supplemented lot. Hematocrits and hemoglobin increased in a linear pattern with the lysine supplementation (35 to 43 and 10.4 to 13.7 in lots 1 and 5, respectively). Gamma globulin decreased (21.7% to 17.4%) and albumin increased (35.6% to 48%) linearly as the lysine level increased. Alpha and Beta globulins decreased to a lesser degree with supplementation. Increases in weight of the spleen, liver, and kidney occurred in the supplemented lots. From this blood pattern it appeared that lysine level might affect tolerance, thus, 3-pigs with malignant melanomas were fed corn-peanut meal rations supplemented with 1.5% L-lysine (HCl). The tumor growth was down graded from 3 to 1 and considerable regression of tumor pigment occurred in two of the pigs. Complete regression of the tumor occurred in the third. Pigs lost a noticeable amount of pigmentation from the dermis and related structure. No control was used, thus no conclusions drawn.

107. EFFECT OF HIGH LEVELS OF COPPER AND CHLORTETRACYCLINE ON PERFORMANCE OF PIGS. R. J. Bunch*, V. C. Speer, V. W. Hays and J. T. McCall, *Iowa State University, Ames.*

Three feeding trials involving 264 pigs were conducted to study the effects of $CuSO_4$ (250 ppm Cu), CuO (250 ppm Cu), and chlortetracycline (50 mg./lb.) on performance of pigs. In the first trial each of the chemotherapeutics improved rate of gain and feed efficiency when fed to 200 lb. or when fed to 125 lb. and withdrawn thereafter, with the exception of $CuSO_4$ fed to 200 lb. which did not improve gains. The treatment comparisons, rate of gain, feed/gain and Cu content of hepatic tissue and *longissimus dorsi* (ppm of dry matter) were as follows: $CuSO_4$ to 200 lb. 1.38, 3.18, 278, 7.3; $CuSO_4$ to 125 lb. 1.47, 2.91, 51, 9.0; CuO to 200 lb. 1.46, 2.89, 93, 10.3; CuO to 125 lb. 1.40, 2.99, 54, 8.2; chlortetracycline to 200 lb. 1.47, 3.02; chlortetracycline to 125 lb. 1.49, 2.99; and control 1.38, 3.24, 23, 6.1. Correlations of —.4 and —.05 were observed for the Cu and Fe content of hepatic and *longissimus dorsi* tissue respectively. An 8-week experiment was conducted to study the effect of supplemental Fe (141 ppm) and Zn (163 ppm) on the response to $CuSO_4$ (250 ppm Cu). Pigs receiving Cu gained significantly faster (55.4 vs. 52.4 lb.). Hb. values were markedly lowered in the presence of added Cu without supplemental Fe. In the third experiment half of the feed from the same ration treatments as trial 2 was brought to 20% moisture and stored at 90° temperature in an attempt to produce rancidity in the feed. The pigs receiving added Cu gained significantly faster (1.97 vs. 1.85 lb./day) and adding moisture to the ration and storage at high temperature did not significantly influence the response to copper. In both trials 2 and 3, supplemental Zn appeared necessary for maximum response to supplemental Cu.

108. VITAMIN A, METHIMAZOLE AND THYROPROTEIN IN CATTLE AND SWINE RATIONS. Wise Burroughs*, V. W. Hays, V. C. Speer and O. C. Simpson, *Iowa State University, Ames.*

Methimazole (Tapazole) feeding (15 to 20 mg./lb. ration) to both beef cattle and swine resulted in increased liveweight gain (about 15%) and improved feed efficiency (about 15%) when finishing rations were fed containing relatively low levels of vitamin A activity (less than about 1,500 I.U./lb. ration) for periods of time up to 2 to 3 mo. duration. When finishing rations containing higher levels of vitamin A activity were fed, no benefits or negative benefits resulted from the feeding of this goitrogenic compound to both species of animals. The incorporation of minute amounts of thyroprotein in the ration (1 to 4 mg. Protamone/lb.) appeared to enhance the effectiveness of methimazole in the low vitamin A finishing rations for both swine and beef cattle. Conversely, the incorporation of similar low-levels of thyroprotein in finishing rations containing relatively high levels of vitamin A appeared to aggravate the effectiveness of methimazole. Beef and pork carcass characteristics (grade and degree of fatness) resulting from methimazole feeding in the relatively low vitamin A rations appeared to be either unaltered or slightly improved based upon current common standards of evaluation.

109. NUTRIENT VALUE OF CORN, SORGHUM AND DWARF CORN SILAGES. J. H. Byers* and K. A. Kendall, *Department of Dairy Science, University of Illinois, Urbana.*

Yield per acre, milk production and digestibility data with dairy cattle were used to study the nutritive value of corn (C) sorghum (S), and dwarf corn (DC) silages. Yields per acre in tons were: (1) green forage: (C) 20.6, (S) 21.0, (DC) 18.4; (2) dry matter: (C) 6.57, (S) 6.31, (DC) 5.54 and (3) crude protein: (C) 0.51, (S) 0.49, (DC) 0.48. Three equalized groups of nine cows each were fed 1 lb. of grain/3.5 lb. of FCM, 1 lb. of hay/100 lb. of body weight and the respective silages *ad libitum*. Average pounds of FCM per cow/day for 119 days were (C) 34.1, (S) 33.1 and (DC) 37.6. Pounds of FCM produced/pound of dry matter consumed were (C) 1.02, (S) 0.96 and (DC) 1.08. Twelve observations using four dairy steers showed dry matter digestibilities to be (C) 68.83, (S) 62.45, and (DC) 70.31. TDN calculated from digestion coefficients show (C) 70.89, (S) 55.27, and (DC) 77.69. Yields of digestible protein per acre were (C) 0.29, (S) 0.23, and (DC) 0.28 tons. TDN yields were (C) 4.66, (S) 3.49, (DC) 0.28 tons. TDN yields were (C) 4.66, (S) 3.49, (DC) 4.30 tons per acre. The data indicate that when yield per acre, milk production and digestibility of the three silages are considered together, corn silage is of the highest nutritive value/acre followed by dwarf corn and sorghum silages. When only the nutritive value of a pound of the respective silages on a dry matter basis is considered the data suggest dwarf corn is superior to corn silage followed by sorghum silage.

110. *IN VITRO* TECHNIQUE FOR STUDYING RUMEN PROTOZOAL FERMENTATION. W. C. Christiansen*, L. Y. Quinn and W. Burroughs, *Iowa State University, Ames.*

The mass that rumen protozoa contribute to the total rumen microorganisms present in cattle and sheep coupled with preliminary evidence suggesting that protozoa are capable of altering large amounts of starch and other carbohydrate fed to ruminants was the stimulus for developing the present *in vitro* technique. The basis of measurement for the technique was total titratable fatty acids produced by rumen protozoa. The reliability of this method was demonstrated in several trials showing low variability

within treatments and with a sensitivity adequate to show differences between treatments. Protozoal populations were harvested from the rumen fluid from the floor, middle and top of the rumen of a fistulated steer. Incubating the collected rumen fluid for 2 to 3 hours in separatory funnels with 1.0% added maltose and sucrose enabled the protozoa to be separated from other rumen constituents. Nutrient and bacterial depletion was accomplished by incubating the protozoa 16 to 18 hours in a buffered medium containing antibiotics. Subsequent fermentations were then conducted using a modified artificial rumen technique and a basal medium meeting protozoal requirements. It was shown that the following conditions were optimal for the *in vitro* culturing of rumen protozoa: (1) pH of 7.5 to 5.5, (2) fermentation time of 16 to 20 hours, (3) substrate concentration of 3 to 4%, and (4) adequate concentration of protozoa in the fermentation medium.

111. GROWTH AND PRODUCTION IN BEEF HEIFERS AS AFFECTED BY PROTEIN AND ENERGY INTAKE DURING GESTATION. D. C. Clanton*, D. R. Zimmerman and J. K. Matsushima, *University of Nebraska, Lincoln.*

Thirty-two bred yearling heifers were divided into four groups of eight head each. They were individually fed one of four rations for 140 days during the winter. (Ration 1: 2.3% D.P. and 669 kcal. M.E./lb.; Ration 2: 2.9% D.P. and 862 kcal. M.E./lb.; Ration 3: 5.4% D.P. and 713 kcal. M.E./lb.; Ration 4: 5.6% D.P. and 916 kcal. M.E./lb.). Each heifer was fed on the basis of her weight, 12 lb. for a 695 lb. heifer. The heifers were individually fed 3 lb. of corn and all the alfalfa hay they would eat during the summer. The average total weight gains during the winter were as follows: Ration 1: −10 lb.; Ration 2: +61 lb.; Ration 3: +20 lb.; Ration 4: +116 lb. The heifers that gained the least, or lost weight during the winter, gained the most during the summer; however, they did not catch up to the high gaining heifers. The heifers fed the high energy rations grew significantly more during the year than those fed low energy rations. The difference in the effect of two protein levels on growth was not significant. Varying the energy level had a significant effect on body condition; varying protein level did not. Hay consumption during the summer did not appear to be affected by wintering treatment. Milk production was determined by weighing the calves before and after nursing. Five 24-hour periods were measured during the summer. There were no significant differences in milk production; however, animal variation was great. The birth weights and corrected 180 day weaning weights, in this order, for the four rations were: Ration 1: 61.4 and 294 lb.; Ration 2: 64.9 and 308 lb.; Ration 3: 64.4 and 324 lb.; and Ration 4: 69.0 and 292 lb. These differences were not significant.

112. EFFECT OF ENERGY, PROTEIN LEVELS AND AMINO ACID SUPPLEMENTATION OF SWINE RATIONS ON CARCASS QUALITY. A. J. Clark*, G. R. Wagner, V. W. Hays, J. T. McCall and V. C. Speer, *Iowa State University, Ames.*

Three experiments involving 492 pigs were conducted to study the effect of protein, energy and sex on carcass quality. Increasing the productive energy level from 950 to 1170 Cal./lb. produced significantly ($P<.05$) more backfat (1.12 vs. 1.22 in.), less lean cuts (54 vs. 52%), and increased the intramuscular fat of the *longissimus dorsi* (10 vs. 13%). Increasing the protein level 13 to 19 to 25% significantly decreased backfat (1.26, 1.20 and 1.06 in.), increased lean cuts (52, 53 and 53%), and decreased intramuscular fat (15, 11 and 9%). Barrows yielded less lean cuts (52 vs. 54%) with more intramuscular fat (13 vs. 10%) than gilts. In trial II increasing the metabolizable energy from 1310 to 1640 Cal./lb. significantly increased backfat (1.05 vs. 1.25 in.), decreased lean cuts (58 vs. 56%) and increased the intramuscular fat in the Serratus ventralis (18 vs. 20%). Increasing the protein from 13 to 19 to 25% significantly decreased backfat (1.22, 1.15 and 1.08 in.), increased lean cuts (56, 57 and 58%) and decreased the intramuscular fat (21, 19 and 17%). Boars yielded more lean cuts (58 vs. 56%), and less intramuscular fat (19 vs. 20%) than gilts. In trial III increasing the metabolizable energy from 1290 to 1730 Cal./lb. significantly increased backfat (1.47 vs. 1.74 in.) and decreased lean cuts (52 vs. 50%). Increasing the protein levels from 12 to 15 to 18% significantly decreased backfat (1.67, 1.60 and 1.54 in.) and increased lean cuts (50, 51 and 52%). Amino acid supplementation (0.1% Met. and 0.1% Lys.) did not appreciably affect backfat or % lean cuts but there was a significant interaction of protein, energy and amino acids on backfat and % lean cuts.

113. SOME NUTRITIONAL AND PHYSIOLOGICAL EFFECTS OF ENZYMES FOR FATTENING CATTLE. J. D. Clark*, I. A. Dyer and J. A. Templeton, *Washington State University, Pullman.*

Twenty-seven Hereford steers were allotted into three groups of nine animals each and placed on full feed for 105 days. Group one served as the control. Animals in group two received the control ration and 3.4 gm. per day of a commercial enzyme mixture which contained primarily proteolytic and amylolytic enzymes (Rhozyme F–3C). Steers of group three received the control ration and 3.4 gm. per day of an enzyme mixture containing primarily proteolytic, amylolytic and cellulolytic enzymes (Rhozyme F–4D). For the first 56 days the ration was composed of 80% concentrate and 20% chopped alfalfa hay. The concentrate was increased to 85% after the 56th day of the test. Average daily gains for the first 56 days were 3.48, 4.30 and 4.15 lb. and for the entire feeding period, 3.05, 3.44 and 3.48 lb. for groups 1, 2 and 3, respectively. These differences were not significant. Control animals required 5% and 8% more feed per pound of gain than those receiving Rhozyme F–3C and Rhozyme F–4D, respectively. The enzyme supplemented steers also had a slightly higher USDA grade than the control steers. Total gas production of rumen fluid from animals of each treatment group was obtained in a Warburg respirometer. The average number of micromoles of gas production per minute was 25.79, 18.57 and 28.02 for the control, Rhozyme F–3C and Rhozyme F–4D, respectively. When the individual enzyme mixtures were added to rumen fluid from a control animal the total gas production was increased.

114. RESPONSE OF PIGS TO IMPROVED PROTEIN QUALITY AND LYSINE. A. J. Clawson* and E. R. Barrick, *North Carolina Agricultural Experiment Station, Raleigh.*

Ten percent protein corn-soy rations were formulated so that 12.5, 25 and 50% of the protein was supplied by dehulled soybean meal. These rations were fed without and with 0.4% of added lysine during two consecutive seasons. Six replications of individually fed pigs were used during each season. The average twelve week daily gain, feed intake and feed per pound of gain were significantly influenced by treatment. The respective daily gains, feed intake and feed/gain ratio for the diets providing 12.5, 25 and 50% of the protein from soybean meal were as follows: Summer trial—0.69, 2.97, 4.33; 1.00, 3.81, 3.79; 1.79, 5.89, 3.29; with lysine 0.86, 2.84, 3.30; 1.59, 4.99, 3.18; 1.84, 6.11, 3.32. Winter trial—0.92, 4.03, 4.39; 1.11, 4.69, 4.22; 1.61, 5.81, 3.61; with lysine 0.86, 3.48, 4.05; 1.31, 5.08, 3.86; 1.68, 5.93, 3.53. Lysine was of most benefit in improving daily gain and feed per lb. of gain in rations of low protein quality. The backfat thickness and area of loin eye muscle for the respective levels of soybean meal were as follows: Summer trial—1.46, 3.96; 1.34, 4.18; 1.31, 4.79; with lysine—1.24, 4.66; 1.32, 5.13; 1.37, 4.92; Winter trial—1.48, 3.22; 1.51, 3.01; 1.63, 4.78; with lysine 1.50, 4.13; 1.55, 4.36; 1.62, 4.52. Area of loin eye muscle was significantly improved ($P<0.5$) by both improved protein quality and by the addition of lysine.

115. FACTORS INFLUENCING THE TOXICITY OF INJECTED GOSSYPOL. A. J. Clawson* and Frank Smith, *North Carolina Agricultural Experiment Station, Raleigh.*

Forty weanling rats were used in an experiment of factorial design to test the effect of dietary protein level (20 versus 10%) on the toxicity of injected gossypol. After a two-week preliminary feeding period, one group of 10 rats fed each diet was injected with either cottonseed oil or cottonseed oil containing 2 mg. of gossypol acetate per ml. The gossypol was injected I.P. at the rate of 1.5 mg. per 100 gm. of body weight. During the first week post-injection, rats which received gossypol lost 6 and 7 gm. respectively on the diets containing 20 and 10% protein; whereas, rats receiving cottonseed oil alone gained 30 and 26 gm. respectively. Rats that did not succumb to the gossypol toxicity were recovering as evidenced by the improvement in gains three weeks post-injection. Therefore, some mechanism must be available for detoxification of injected gossypol. This mechanism did not respond to a difference in protein intake such as takes place when gossypol is fed. Ninety-six weanling rats were used in a second experiment in which the following variables were used with rations containing either 10 or 30% protein: (1) injected corn oil; (2) injected corn oil plus gossypol and (2) plus the following: injectable iron (dextran), dietary iron (ferrous sulfate), dietary lysine, dietary iron and lysine. Iron dextran injected into the peritoneal cavity simultaneously with the corn oil containing gossypol was more effective in overcoming gossypol toxicity than either dietary iron or lysine.

116. DIGESTIBILITY OF PIG STARTER RATIONS CONTAINING VARIOUS SOURCES OF PROTEIN. G. E. Combs*, F. L. Osegueda, H. D. Wallace and C. B. Ammerman, *University of Florida, Gainesville.*

Pigs weaned at 2 weeks of age were individually fed rations containing soybean meal (SM) or peanut meal (PM), trial 1, and dried skim milk (DSM), fish meal (FM) or SM, trial 2, as the source of supplementary protein. Coefficients of digestion for dry matter, nitrogen, ether extract, energy and ash were determined by the use of Cr_2O_3 when the pigs were 3 to 4 (period 1) 5 to 6 (period 2) and 7 to 8 (period 3) weeks of age. In trial 1 the daily gain and feed efficiency of pigs fed SM were significantly different ($P<.01$) from those fed PM. During periods 1 and 2 digestion coefficients were similar for both treatments. In period 3 the coefficients of digestion for all items studied were significantly higher ($P<.01$) with pigs fed the SM rations. Digestibility of the PM ration was similar for all periods studied whereas with SM the digestion coefficients were similar only for periods 1 and 2; period 3 was significantly higher than periods 1 and 2 ($P<.01$). Performance data collected in trial 2 showed that pigs fed rations containing either DSM, SM or FM differed significantly in both rate and efficiency of gain. Significant differences in the coefficients of digestion were also found when rations within a period and periods within a ration were compared. With the exception of ash all significant differences concerned with ration comparison were limited to periods 1 and 2. Differences among periods within a ration along with treatment means will be presented.

117. ANTIBIOTIC POTENTIATION IN THE PIG GROWER RATION. R. A. Costain*, and L. E. Lloyd, *Macdonald College (McGill University), Quebec, Canada.*

A study was made of the effect of terephthalic acid (TPA) and ration calcium level on blood serum terramycin levels and on the growth, feed intake and nutrient digestibility of growing pigs from 9–16 weeks of age. The trial took the form of a 2 x 2 x 3 factorial design, 48 Yorkshire x Landrace pigs being placed on test in four replicates of six males and six females. Two 16% protein rations containing either 0.85% or 0.42% calcium were fed, each ration being supplemented with nil, 200 gm./ton terramycin or 200 gm./ton terramycin + 8 lb./ton TPA. Blood samples were taken via an anterior vena cava puncture at 14 weeks of age, and the serum was assayed for terramycin. Pigs receiving the terramycin and terramycin + TPA exhibited significantly ($P<0.05$) greater daily gains and feed consumption than the unsupplemented controls. This effect was more marked with the animals receiving the low calcium ration, the calcium x antibiotic interaction being significant ($P<0.05$). The terramycin assay of the blood serum revealed a similar trend. The potentiating effect of the TPA was only evident when the ration contained 0.42% calcium, serum terramycin levels being twice as great as those in pigs receiving the higher calcium ration. The inclusion of terramycin or terramycin + TPA to the ration was without effect on efficiency of feed conversion, but a reduction in calcium level brought

about a significant ($P<0.05$) improvement in feed efficiency. These results indicate that a combination of TPA and reduced calcium level is required for maximum antibiotic potentiation.

118. EFFECT OF SODIUM BICARBONATE, SODIUM ACETATE AND STRYCHNINE SULFATE ON THE PERFORMANCE OF BEEF ANIMALS RECEIVING A PELLETED RATION. A. E. Cullison* and C. S. Ward, *University of Georgia, Athens.*

Six groups of 10 steer calves each were carried through a 168-day winter feeding period on the following treatments, respectively: (1) concentrates and long hay; (2) same ration, pelleted; (3) pelleted ration + oat straw, *ad lib.;* (4) pelleted ration + 0.5% $NaHCO_3$ in the drinking water; (5) pelleted ration + 0.5% $NaC_2H_3O_2$ in the drinking water; (6) pelleted ration + up to 960 mg. strychnine sulfate per 100 lb. feed. The ADFC, and the ADG, respectively, for the various groups were as follows: (1) 15.51, 1.75; (2) 13.41, 1.58; (3) 15.99 + 1.38 straw, 2.05; (4) 16.03, 1.99; (5) 14.21, 1.84; (6) 13.81, 1.66. Group 2 was significantly different from Groups 3 and 4 in ADG. Also, Group 2 exhibited a rumen pH level which was significantly below that of the other groups. Those steers receiving water containing $NaHCO_3$ or $NaC_2H_3O_2$ drank more water than did comparable steers receiving plain water. No specific deleterious effects were noted with any of the treatments used. In a second trial, six lots of 10 two-year-old steers each were carried through a 56 day summer feeding period on the following treatments, respectively: (1) pellets only; (2) pellets + oat straw, *ad lib.;* (3) pellets + 0.5% $NaHCO_3$ in the drinking water; (4) pellets + oat straw, *ad lib.*, + 0.5% $NaHCO_3$ in the drinking water; (5) pellets + 0.25% $NaHCO_3$ in the drinking water; (6) pellets + 0.75% $NaHCO_3$ in the drinking water. The ADG for the various groups were as follows: (1) 1.49; (2) 2.39; (3) 1.21; (4) 2.11; (5) 1.38; (6) 1.64. An interaction of the $NaHCO_3$ treatment on environmental temperature and/or age of animal is indicated.

119.

120. FIBER-ENERGY-PROTEIN RELATIONSHIPS IN RATIONS FOR SWINE. W. E. Dinusson*, D. W. Bolin, and D. L. McIlroy, *North Dakota State University, Fargo.*

In continuation of research a barley and oats rations for swine, three experiments of factorial design involving 150 pigs were conducted to study effect of varying hull content (fiber) on energy and protein utilization. Hulled oats were used as the base grain and oat hulls used to vary the fiber levels. Corn and linseed oil meal was used to vary the protein levels. The experiments were carried out on concrete floors, cleaned daily. Measurements of gain, feed efficiency, protein and fiber digestibility, and digestible energy were taken. The following results were obtained. Pelleted rations were significantly better ($P=0.5$) than meal as measured by daily gain and feed per pound of gain. Increasing fiber (as oat hulls) from 2.9 to 16% did not significantly effect rate of gain on pelleted rations. Varying protein level from 11 to 16% did not significantly effect rate of gain. Using oat hulls as 30 and 45% of the ration (12 and 16% fiber rations) significantly decreased feed efficiency and protein digestibility. The fiber of oat hulls was not digested. Protein digestibility was lower when determined on wet instead of dry feces. The differences in protein digestibility by the two methods (wet vs dry feces) increased with increasing fiber content. Pigs ate on an energy basis, not on pounds of feed. With pelleted rations with each increase in fiber level they increased intake to attempt an equal daily energy intake.

121. RUMEN BIOPSY TECHNIQUE AND ITS APPLICATION. L. Dozsa, G. C. Anderson* and G. A. McLaren, *West Virginia University, Morgantown.*

Recent findings suggest that the rumen mucosa may be of considerable metabolic significance. Further the character and possible functions of this tissue may be influenced by the physical nature and composition of the rumen ingesta. Definitive studies of these possible functions and their interrelationships would be enhanced if suitable amounts of tissue could be obtained from the living animal. A series of biopsies were performed on a fistulated sheep using a uterine biopsy forceps. A rumen wall area about 10 in. in diameter opposite the fistula could be sampled satisfactorily. A malleable type forceps which is being developed should permit an extension of the sampling area. A slight inappetance was observed after the first biopsy. Subsequent biopsies did not appear to effect the lamb. Fifty biopsy samples were obtained over a 224-day period during which time three types of roughage, alfalfa pellets and a semi-purified high-urea ration were fed. Histological study of biopsy material showed definite structural changes which could be associated with the ration fed. The applicability of the technique for obtaining biochemical assay material was studied. A single biopsy yielded from 25–50 mg. of tissue. The metabolic activity of biopsy material in terms of glutamic dehydrogenase was comparable to that of similar tissue obtained from freshly slaughtered lambs.

122. EFFECT OF FEEDING SODIUM ACRYLATE WITH AND WITHOUT CHLORTETRACYCLINE TO SWINE. J. J. Drain*, D. D. Johnson, and R. G. Eggert, *American Cyanamid Company, Princeton, New Jersey.*

Six experiments were conducted to evaluate sodium acrylate (SA) with and without chlortetracycline (CTC) as an additive for swine rations. In two experiments conducted at Princeton, 224 weanling crossbred pigs were assigned to eight treatment groups and performance studied. Average daily gains and feed efficiencies from 28 to 125 lb. follow: basal, 1.07, 2.92; SA(500 G/T), 1.28, 2.73; SA(1000 G/T), 1.25, 2.98; SA(2000 G/T), 1.22, 2.80; CTC(50 G/T), 1.37, 2.99; CTC(50 G/T) + SA(500 G/T), 1.45, 2.73; CTC(50 G/T) + SA(1000 G/T), 1.54, 2.70; CTC(50 G/T) + SA(2000 G/T), 1.46, 2.88. Statistical analysis of gains revealed the main effects for both CTC and SA were significant ($P<.01$). No differences existed among levels of SA and there was no CTC X SA interaction. Feed efficiency was generally improved by SA, although not significantly. Four additional feeding experiments were conducted in Iowa under farm conditions. CTC was fed at

50 G/T from 35 to 75 lb.; thereafter the level was reduced to 20 G/T. Sodium acrylate was incorporated at 1000 G/T. Average daily gains and feed efficiencies for 389 pigs from 35 lb. to market weight are reported: basal, 1.50, 3.66; SA, 1.50, 3.62; CTC, 1.61, 3.54; CTC + SA, 1.63, 3.46 (standard errors of difference = 0.05, 0.04). Significantly greater gains were associated with CTC supplementation ($P<.01$). Feed conversion was improved by both CTC ($P<.01$) and SA ($P<.05$).

123. RESPONSE OF THE BABY PIG TO LEVELS OF DIETARY CALCIUM. W. A. Dudley*, D. E. Becker, H. W. Norton and A. H. Jensen, *University of Illinois, Urbana.*

Three experiments were conducted to investigate the response of the baby pig to levels of dietary calcium and the influence of the dietary carbohydrate thereon. Glucose and lactose were compared when they were used as the principal source of energy in the diet. Ninety-six pigs at 14 days of age were used. Each treatment group of four pigs was fed *ad libitum* for 5 or 6 weeks. In addition to the carbohydrate, the diet contained crude casein to provide 21% protein. The control diet analyzed 0.1% calcium and 0.8% phosphorus, the latter supplied largely as $NaH_2PO_4 \cdot H_2O$. Levels of supplementary calcium were supplied as USP $CaCO_3$. The criteria were rate of gain, gain-feed ratio, ash content of the dry, fat-free femur and blood calcium level. After 2 to 4 weeks on test, pigs fed the unsupplemented diet developed symptoms of calcium deficiency which were manifested as weak legs and pasterns, impaired locomotion, and seizures of calcium tetany which frequently culminated in death. The nature of the dietary carbohydrate did not influence the occurrence of the deficiency symptoms or influence the calcium requirement. The rate and efficiency of gain were greater on lactose than on glucose in only one trial, and in another trial the femur ash at all levels of calcium was higher with lactose than with glucose. For maximum rate and efficiency of gain the calcium requirement was no higher than 0.2% of the diet. On the other hand, the ash content of the femur increased with all increments of calcium up to 2.0% of the diet.

124. EFFECTS OF HIGH SALT INTAKE ON DIGESTIBILITY IN CATTLE. C. J. Elam*, *Beef Cattle Research Branch, ARS, USDA, Beltsville, Maryland.*

Four Hereford steers were used in a balanced 4 x 4 extra-period Latin-square-designed experiment. Each period included an 18-day preliminary and a 10-day collection period. One, 2, 4, and 8% levels of NaCl were added to a basal ration of grass hay, corn, CSM, and bonemeal. Steers were fed the pelleted rations twice a day at 1.7% of body weight and water was available *ad lib.* Urine and feces were collected using digestion crates. The average digestibility of organic matter, energy, crude fiber (CF), and crude protein (CP) was decreased significantly by the 8% level of NaCl. Two % NaCl decreased ether extract digestibility, but increased CF and CP digestion. Water consumption and urine excretion were increased by each level of NaCl above the 2% level. Rate of passage (RP), measured by the percentage of a dose of chromic oxide that was excreted in 48 hr., tended to increase with increasing levels of NaCl. The average percent of chromic oxide dose excreted was 66.5, 69.7, 71.4, and 74.5 for treatments of 1, 2, 4, and 8% NaCl, respectively. RP was significantly faster for the 8% NaCl than the 1% NaCl treatment.

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126. EFFECT OF PROTEIN-ENERGY ON STEER PERFORMANCE AND RUMEN VOLATILE FATTY ACIDS. E. S. Erwin*, J. Algeo and R. S. Gordon, *Monsanto Chemical Company, St. Louis, Missouri.*

In a 2 x 2 factorial study, 144 yearling steers were fed for 126 days rations that varied in protein (P) content (11% and 19%) and energy (E) level (71 and 80 therms/100 lb.). When protein was increased, growth and feed utilization were reduced by 0.10 and 0.60 lb. respectively. While high energy diets did not alter growth rate, 0.36 lb. less feed was required per lb. gain. Elevation of dietary energy significantly increased the molar % of rumen propionate with a corresponding decrease in acetate. Increases in either dietary energy or protein or both decreased rumen butyrate and significantly increased isovalerate and valerate. The dietary changes did not alter dressing % but grade was markedly affected. The % of the steers that graded US choice in each treatment group was: Low P—High E, 75; High P—Low E, 79; Low P—High E, 78; High P—High E, 36.

127. EFFECT OF PROTEIN, ENERGY, AND ANTIOXIDANT ON HEPATIC VITAMIN A IN STEERS. E. S. Erwin, R. B. Grainger*, J. Algeo, and R. S. Gordon, *Monsanto Chemical Company, St. Louis, Missouri.*

For 70 days, yearling steers (144) were fed vitamin A—carotene free rations with two protein levels (11% and 19%) and two energy levels (70 and 81 therms/100 lb.) with and without the antioxidant, Santoquin—1, 2-dihydro-6-ethoxy-2, 2, 4-methyl quinoline (.0125%). Energy increase was accomplished by the removal of oat hay and by the addition of cottonseed foots. Half the steers in each dietary treatment were initially injected intraruminally with 1 million iu. vitamin A. Only the hepatic vitamin A retention of the vitamin A injected steers were used to interpret dietary effects, since many of the steers in the uninjected group established a final vitamin A concentration of 1–2 mcg./gm. of liver which suggested that the animals were drawing upon extrahepatic vitamin A storage sites. The mean initial and final liver vitamin A levels of all non-injected steers were 52.6 and 8.6 mcg./gm. fresh liver. Increasing the dietary protein and energy levels each significantly accelerated hepatic vitamin A expenditures while Santoquin significantly reduced the liver vitamin A loss.

128. EFFECTS OF PHYSICAL FORM OF DIFFERENT PARTS OF A LAMB-FATTENING RATION. J. P. Fontenot* and H. A. Hopkins, *Virginia Agricultural Experiment Station, Blacksburg.*

During each of 2 years, a feeding trial involving 80 lambs and three digestion trials involving 16

lambs each were conducted. Physical forms were as follows: (1) ground concentrates (conc.)—long hay; (2) ground conc.—ground hay; (3) ground conc.—pelleted hay; (4) pelleted conc.—long hay; (5) pelleted conc.—ground hay; (6) pelleted conc.—pelleted hay; (7) entire ration mixed and pelleted; (8) entire ration mixed, pelleted and reground. The concentrate to hay ratio was maintained at 1:1. The concentrate portion consisted of 90% shelled corn and 10% cottonseed meal and the hay was alfalfa. The lambs in the feeding trials were full fed and those in the digestion trials were fed equal amounts of feed. Pelleting the hay increased feed intake (about 10%), rate of gain ($P<.05$) and feed efficiency, as compared to ground or long hay. Grinding or pelleting hay significantly depressed crude fiber digestibility, the effect being especially pronounced when concentrates were pelleted (hay X concentrates interaction was significant). Pelleting concentrates depressed feed intake 6%, had no effect on rate of gain and increased feed efficiency 9%. Pelleting the entire ration increased feed intake, rate of gain ($P<.05$), feed efficiency (16%) and protein digestibility ($P<.05$) and significantly decreased fiber digestibility, as compared to ground ration. When the pellets were reground feed intake, rate of gain, and feed efficiency tended to be intermediate between those when the ground and pelleted rations were fed. Grinding the pellets tended to restore fiber digestibility to the level obtained when the ground ration was fed.

129. OXIDATION OF VOLATILE FATTY ACIDS AND OTHER METABOLITES BY RUMEN.

J. R. Fordham* and L. V. Packett, *Purdue University, Lafayette, Indiana.*

Lambs were sacrificed by exsanquination and rumen papillae were taken from the rumen just caudal to the rumino-reticular fold. The papillae were incubated at 37° C in Warburg flasks containing 3 ml. of (1) bicarbonate buffer, (2) buffer containing 20 micromoles of glucose or (3) buffer containing 60 micromoles of a mixture of 67% acetic, 19% propionic and 14% butyric acid. The Qo_2 of tissues incubated with substrates 1, 2 and 3 were 3.95, 4.63 and 5.39 respectively for the first hour. This had decreased to 0.52, 1.99 and 3.96 respectively for the third hour. There was a substantial variation in the rate of oxidation of the substrates by papillae from different lambs which could not be correlated to rate of gain. A series of experiments was conducted with papillae from eight fattening lambs to determine the rate of metabolism of glucose, citrate, propionate, acetate, succinate and their combinations. When a single substrate was used, glucose exhibited the greatest rate of oxidation followed by propionate, citrate and acetate in decreasing order. When combinations were compared, the papillae oxidized glucose-citrate at the greatest rate followed in decreasing order by acetate-propionate, acetate-citrate and propionate-citrate. The Qo_2 was increased when citrate was added to glucose, however, the Qo_2 was lower with combinations of citrate-acetate of citrate-propionate than in any of the metabolites alone or with buffer alone. This would suggest a possibility of lowering of the specific dynamic action of acetate or propionate by the presence of citrate. The greatest rate of oxidation was obtained with a combination of propionate-succinate which was consistently greater than the propionate-citrate combinations.

130. EVALUATION OF SOYBEAN HULLS FOR BEEF STEERS.

Robert R. Garrigus*, N. W. Bradley, C. O. Little and G. E. Mitchell, *University of Kentucky, Lexington.*

The chemical analysis of soybean hulls suggests that, except for a low carotene content, they should make an adequate ration for stocker steers. Forty-eight Hereford steers averaging 430 lb. were divided into four lots and fed soybean hulls for 168 days processed as follows: Lot I—flaked; Lot II—ground; Lot III—pelleted; and Lot IV—ground for 84 days then reground pellets for 84 days. Vitamin A (3600 IU per steer per day) and free choice minerals were provided in all lots. Feed per cwt. gain and average daily gain, respectively were: Lot I—916 and 1.20; Lot II—966 and 1.12; Lot III—722 and 1.50 ($P<0.01$); and Lot IV—791 and 1.48 (last 84 days). Molar percentages of butyric, propionic and acetic acids in rumen fluid samples were 3.8, 19.9, and 76.3; 2.0, 20.7, and 77.3; 5.4, 22.5 and 72.1; and 4.8, 25.5, and 69.7 for lots I through IV, respectively. Preliminary values (four of eight animals on each treatment) for digestible energy, digestible protein and nitrogen balance were: Lot I—68%, 52%, and + 15gm.; Lot II—75%, 71%, and + 35gm.; Lot III—74%, 71%, and + 32gm.; and Lot IV—73%, 71%, and + 27gm.

131. PROTEIN REQUIREMENTS OF FATTENING CATTLE AND THE EFFECTS OF VARIOUS FEED ADDITIVES.

R. D. Goodrich*, L. B. Embry, G. F. Gastler and F. W. Whetzal, *South Dakota State College, Brookings.*

A 4 x 5 factorial design was used in a fattening experiment (200–202 days) with 200 head of yearling Hereford steers (av. shrunk wt. 591 lb.). Protein levels of 9.5, 10.6, 12.0 and 12.7% were used with the following daily levels of feed additives: control, 10 mg. diethylstilbestrol (DES), 2 gm. dynafac (TAS), 15 mg. diallystilbestrol (DAS) and a combination of DES and TAS. A basal ration of 20% brome-grass hay—80% rolled shelled corn plus 1 lb. of protein-mineral supplement per 10 lb. of hay-grain mix was fed to the 9.5% protein lots. For the 10.6, 12.0 and 12.7% protein rations, 4.0, 8.1, and 12.2% of the rolled shelled corn was replaced with an equal weight of soybean oil meal. Gains and feed efficiencies were: 2.42, 925; 2.55, 878; 2.46, 885 and 2.39 and 903 lb. respectively for protein levels of 9.5, 10.6, 12.0 and 12.7%. Gains and feed efficiencies for the additives were: control, 2.32, 928; DES, 2.61, 873; DAS, 2.42, 909; TAS, 2.32, 924 and DES + TAS, 2.60 and 856 lb. respectively. DES and the combination of DES and TAS significantly improved gain 12.5% and 12.1% and feed efficiency 5.9% and 7.8% over controls ($P<.01$). The response to the feed additives did not appear to be affected by the level of protein. DAS resulted in a small but consistent increase in rate of gain ($P<.05$) while TAS did not influence the performance of the cattle in this experiment. With cattle fed an equal length of line,

significant treatment effects on carcass quality were an improvement in conformation score ($P<.01$) with DES or DES + TAS and a decreased dressing percent with DES + TAS ($P<.01$).

132. VALUE OF SUPPLEMENTAL LYSINE AND METHIONINE ANALOG IN HIGH-UREA RATIONS FOR BEEF CATTLE. W. H. Gossett*, W. M. Beeson, T. W. Perry and M. T. Mohler, *Purdue University, Lafayette, Indiana.*

Twelve lots of six Hereford steer calves each were fed a basal ration of rolled shelled corn (full-fed), 15–20 lb. corn silage and either a 32% or 64% protein supplement on the same protein equivalent basis. L-lysine and methionine hydroxy analog were added to the 64% supplement at 5 or 10 gm. daily. 1.54 gm. of trace minerals (Mn, Fe, Cu, Co, I & Zn) were fed to one-half the steers. Steers fed 32% Purdue Supplement A at 2 lb. per head daily gained significantly ($P<.01$) faster (2.64 vs. 2.37) with more efficient feed conversion (826 vs. 851) than steers receiving 1 lb. of 64% supplement. The addition of lysine to the 64% supplement at either the 5- or 10-gm. level did not improve average daily gain. Lysine at 10 gm. daily improved feed efficiency 6.3% (803 vs. 857). Methionine analog fed at 5 gm. daily did not improve daily gain (2.44 vs. 2.43) or feed conversion (851 vs. 857). The addition of methionine analog at 10-gm. daily caused a significant ($P<.01$) depression in rate of gain (2.13 vs. 2.43) and decreased feed efficiency (900 vs. 857). Trace mineral fortification resulted in no significant response in daily gain or feed efficiency. No noticeable differences were observed in Federal carcass grades between the 32 or 64% supplements. The addition of amino acids had no effect on carcass grades except 10 gm. of methionine analog gave significantly ($P<.01$) lower grades. Trace minerals gave slightly better grades.

133. BERMUDA HAY, CITRIC ACID AND YEAST IN STEER RATIONS. R. C. Gray, Jr.* and W. B. Anthony, *Auburn University Agricultural Experiment Station, Auburn, Alabama.*

Good to Choice yearling Hereford steers, averaging 453 lb., were allotted on weight and grade basis to four lots of eight steers each. Pelleted Coastal Bermuda rations were self-fed for 62 days, with ration makeup as follows: I, basal (5% molasses, 1% salt); II, basal plus 5% CSM and 5% ground shelled corn; III, II plus 1% dehydrated alfalfa meal; and IV, II plus 4% alfalfa meal. The cattle were then reallotted, two steers from each previous treatment making up the new lot and were self-fed a finishing ration (30% hay plus concentrate) for 90 days, with ration makeup as follows: basal, basal plus citric, basal plus yeast, and basal plus citric and yeast. Average daily gains for the pelleted phase were 2, 17, 2.34, 2.35, and 2.22. For the finishing phase average daily gain and feed per 100 pounds of gain as determined by regression analysis were 2.66–1060.6, 2.71–1020.8, 2.58–1056.6 and 2.85–1020.7. Statistical analysis showed no significant difference among treatment in either phase. However, steers receiving citric acid supplement did have an increased average daily gain that approached significance.

134. CONCENTRATES FROM DISTILLERS DRIED SOLUBLES AS SOURCES OF UNIDENTIFIED GROWTH FACTORS. J. D. Green*, M. P. Plumlee, J. H. Conrad, W. H. Smith, and W. M. Beeson, *Purdue University, Lafayette, Indiana.*

A total of 72 pigs, six per treatment, approximately 3 weeks old, and weighing about 12 lb. each were used in two feeding experiments to test distillers dried solubies (DDS) and concentrates from DDS as sources of unidentified growth factors. The isolated soybean protein semi-purified diet contained 20% protein, 0.66% calcium, 0.66% phosphorus, and from 100 to 125 ppm zinc. Soybean oil was the source of fat in Experiment I and either soybean oil or corn oil in Experiment II. The treatments for Experiment I were: (1) basal, (2) 5.0% DDS, and (3, 4, 5 and 6) 0.5% of one of four concentrates from DDS respectively. Daily gains varied from 1.13 to 1.29 lb. per day and feed per lb. of gain from 2.30 to 2.40 lb. for the 63 day period. There were no significant differences in gains or feed efficiency between treatments. In Experiment II the treatments were: (1) soy oil-basal, (2) soy oil-basal containing 5.0% DDS, and (3) soy oil-basal plus 40 ml. of a concentrate from DDS equivalent to 5.0% DDS. Treatments 4, 5, and 6 were the same as 1, 2, and 3, respectively, except corn oil was the source of fat. Daily gains varied from 0.79 to 0.94 lb. per day and feed per lb. of gain from 2.24 to 2.40 lb. for the 42-day period. There were no significant differences in daily gain or feed efficiency between the treatments either with respect to source of fat or with respect to the source of unidentified growth factor.

135. EFFECT OF CHELATING AGENTS ON ZINC UTILIZATION BY GROWING SWINE. J. D. Green, M. P. Plumlee*, W. H. Smith, H. E. Parker and W. M. Beeson, *Purdue University, Lafayette, Indiana.*

This study consisted of a Zn^{65} balance trial with 8 barrows and a feeding trial with 36 3-week old pigs. The treatments for the balance trial were: soybean protein basal, soy basal + 450 ppm EDTA, casein basal and casein basal + 0.61% phytic acid (PA). Two 120-lb. pigs were fed each ration for a 6-day preliminary and a 6½-day collection period. Each pig was dosed orally by stomach tube with 0.6 mc. of $Zn^{65}Cl_2$ solution at the start of the collection period. EDTA decreased and PA increased fecal excretion of Zn^{65}. EDTA increased urinary excretion and increased liver storage of Zn^{65}. Highest tissue concentration and least fecal excretion of Zn^{65} were on the casein basal. A soybean meal basal ration which contained 20.9% protein, 0.78% Ca, 0.81% P and 44 ppm Zn was used in the 63 day depletion and the 28 day repletion phases of the feeding trial. Each treatment consisted of three replicates of two pigs each. The treatments, average daily gain and cases of parakeratosis were: soybean meal basal (I), 0.57, 5; basal + 200 ppm Zn (II), 0.95, 0; basal + 450 ppm EDTA (III), 0.81, 0; basal + 0.61% PA (IV), 0.21, 6; basal + 0.61% PA + 200 ppm Zn (V), 1.12, 0; and basal + 0.61% PA + 450 ppm EDTA (VI), 0.84, 0. All lots gained significantly faster ($P<.01$) than lot IV. Both lots II and VI gained significantly faster than lot I and lot V gained significantly faster ($P<.01$) than lots I, III and IV. Reducing the calcium to 0.41% and the

phosphorus to 0.42% improved performance during the repletion period but soaking the ration in water did not improve performance of these selected parakeratotic pigs.

136. THIOFURADENE, VIRGINIAMYCIN, TYLOSIN, AUREOMYCIN AND BACITRACIN FOR GROWING FINISHING SWINE. S. A. Griffin, E. R. Lidvall, Jr. and D. E. McKechnie, *Tennessee Agricultural Experiment Station, Knoxville.*

Eighty-eight weanling Duroc pigs were allotted to 22 lots on the basis of weight and sex. Two lots of 4 pigs each were randomly assigned to each of the following treatments (1) control; (2) control plus 17 gm. thiofuradene per ton of feed; (3) control plus 25 gm. thiofuradene per ton; (4) control plus 37 gm. thiofuradene per ton; (5) control plus 55 gm. thiofuradene per ton; (6) control plus 83 gm. thiofuradene per ton; (7) control plus 125 gm. thiofuradene per ton; (8) control plus 20 gm. aureomycin per ton; (9) control plus 20 gm. tylosin per ton; (10) control plus 20 gm. Virginiamycin per ton; and (11) control plus 40 gm. Virginiamycin per ton. The pigs were fed in concrete pens from a weight of about 44 lb. to an average weight of about 200 lb. Treatment number, average daily gain and feed required per 100 lb. of gain for the period from 44 lb. to 100 lb. are as follows: (1) 1.24, 310; (2) 1.43, 300; (3) 1.44, 308; (4) 1.38, 312; (5) 1.38, 316; (6) 1.37, 316; (7) 1.46, 288; (8) 1.34, 298; (9) 1.45, 309; (10) 1.50, 305; and (11) 1.52, 295. There was a difference ($P<.05$) in the average daily gain during this period. The pigs receiving Virginiamycin gained faster than the controls but there was no difference ($P<.05$) in feed required per 100 lb. of gain. However, for the entire feeding period, there were no differences ($P<.05$) in either average daily gain or feed per 100 lb. gain. Performance was as follows: (1) 1.57, 347; (2) 1.60, 354; (3) 1.61, 367; (4) 1.53, 381; (5) 1.56, 372; (6) 1.54, 366; (7) 1.62, 348; (8) 1.56, 355; (9) 1.66, 369; (10) 1.60, 347; and (11) 1.59, 351.

137. BABY PIG'S PREFERENCE FOR DIETS CONTAINING VARYING LEVELS OF SUCROSE. L. E. Grinstead*, V. C. Speer and V. W. Hays, *Iowa State University, Ames.*

Three hundred and sixty-two pigs were weaned at 2 weeks of age and used in four preference-type trials to determine the baby pig's ability to detect varying levels of sucrose in the diet. Two rations were offered free-choice in each pen. The positions of the feeders within a pen were interchanged three times weekly. All possible combinations of the levels of sucrose tested were compared as follows: 0.0, 2.5 and 10.0% sucrose in Trial I; 0.0, 2.5 and 5.0% sucrose in Trial II; 0.0, 1.25 and 2.5% sucrose in Trial III; and 0.0, 0.625 and 1.25% sucrose in Trial IV. In addition to these comparisons, trials II, III and IV included a control (no sucrose) vs. control comparison. The comparisons and combined consumption percentages for the four trials were: (1) control vs. control, 48%:52%; (2) control vs. 0.625%, 11%:89%; (3) control vs. 1.25%, 18%:82%; (4) control vs. 2.5%, 29%:71%; (5) control vs. 5.0%, 25%:75%; (6) control vs. 10%, 29%:71%; (7) 0.625% vs. 1.250%, 25%:75%; (8) 1.25% vs. 2.50%, 40%:60%; (9) 2.5% vs. 5.0%, 35%:65%; (10) 2.5% vs. 10.0%, 21%:79%; and (11) 5.0% vs. 10.0%, 24%:76%. These results clearly demonstrate that pigs 2 to 6 weeks of age prefer a ration containing sucrose to a ration containing no sucrose and prefer the rations containing higher levels of sucrose. These results also show that pigs of this age can detect dietary sucrose at levels as low as 0.625%.

138. THE EFFECT OF CONCENTRATE LEVEL AND NITRATE ADDITION ON HEPATIC VITAMIN A STORES AND PERFORMANCE OF FATTENING STEERS. W. H. Hale*, Farris Hubbert, Jr., and R. E. Taylor, *University of Arizona, Tucson.*

Twelve steers were allotted to a 2 x 2 factorial experiment in which the factors were energy level of the ration (71.3 and 54.3% T.D.N.) and KNO_3 addition to the ration (none and 1% KNO_3). Cottonseed hulls were used to regulate the T.D.N. content with milo as the grain source. All steers were individually fed the low carotene rations. Liver biopsies were taken at the initiation of the experiment and at 28-day intervals. The high concentrate ration caused a significantly ($P<0.05$) larger depletion of liver vitamin A than did the low concentrate ration. The same trend occurred with the nitrate addition; however, the difference was not significant. Average liver vitamin A values were reduced from 38 mcg. to 6 mcg. in 56 days. Although there was no treatment effect upon average daily gains, there was a significant interaction ($P<0.05$) between the concentrate level and nitrate addition. This was due to the reduction in daily gains when nitrate was fed with the low-concentrate ration (3.18 lb. vs. 2.01 lb.) and an increase in gains due to nitrate with the high-concentrate ration (2.03 lb. vs. 2.29 lb.). Both concentrate level and nitrate addition reduced feed intake ($P<0.05$ and $P<0.01$, respectively).

139. EFFECT OF PANTOTHENIC ACID, PYRIDOXINE OR RIBOFLAVIN ON THE ANTIBODY PRODUCING ABILITY OF SWINE. B. G. Harmon*, J. A. Hoefer, E. R. Miller, D. E. Ullrey and R. W. Luecke, *Michigan State University, East Lansing.*

Two trials were conducted to investigate the effect of deficiencies of each of the three B vitamins, pantothenic acid, pyridoxine and riboflavin upon the antibody producing ability of swine. Baby pigs were placed on a synthetic milk diet devoid of these vitamins at 2 weeks of age. At 4 weeks of age the pigs were uniformly allotted to 4 treatments. Lot 1 received a diet containing NRC recommended amounts of the three B vitamins, while lots 2, 3 and 4 received rations devoid of pantothenic acid, pyridoxine or riboflavin respectively. After the pigs had been on their specified diets for 23 days in trial I and 30 days in trial II (a total depletion time of 37 and 44 days, respectively) a series of six daily antigen injections were commenced. The antigens used were *Salmonella pullorum* in trial I and human red blood cells in trial II. Prior to the administration of the antigen and six days after the last of the injections, agglutination titers were determined for the particular antigen. Following a repletion period the agglutination titers were redetermined using the human RBC in trial I and *S. pullorum* in trial II. The average post-injection agglutination titers for the depletion phase are as follows: Trial I—

control, 204; pantothenic acid, 38; pyridoxine, 40; riboflavin, 36. Trial II—control, 230; pantothenic acid, 24; pyridoxine, 19; riboflavin, 38. The agglutination titers of the control groups were significantly higher than any other treatment in either trial during the depletion phase. Urinary xanthurenic acid determined for the pyridoxine deficient and the control pigs showed a negative correlation with antibody production.

140. TECHNIQUE FOR NAMING AND SUMMARIZING FEEDSTUFFS AND THE USE OF SUCH INFORMATION FOR CALCULATING DIETS. Lorin E. Harris*, *Utah State University, Logan.*

The Association of American Feed Control Officials defines most feeds on the basis of the entire name. This has resulted in many inconsistencies. For example, cottonseed meal does not contain the word "oil" while linseed "oil" meal does. To overcome these difficulties a new system is suggested and can be summarized as follows: (1) It defines terms which make up the component parts of a feedstuff. These include: genus, species, or feed product; part of plant, animal, or feed product; process undergone or method of handling; stage of maturity; cutting; and official grade. Each component is combined to give the name of the feedstuff. (2) Other descriptive information includes origin of sample (country, region, state, or province, county, and literature source) digestibility trial data (species, breed, sex, age, physiological state, number of animals used in trial, and percent of test ingredient in ration fed). (3) A flexible coding system of the component parts of a feed and a method of summarizing the data on IBM machines are outlined. It is suggested that the best use of the data can be made by: (1) Analyzing for and determining the utilization of nutrients that mean something. For example, energy should be on a calorie basis; (2) recording and reporting data on a moisture free basis; (3) describing feedstuffs in detail when reporting in the literature; (4) putting requirements and nutrient analyses on a moisture free basis; (5) calculating diets on a moisture free basis; (6) calculating for mixing to an "as fed" basis. Data of this type can be used in linear programing on IBM machines for calculating diets.

141. EFFECT OF HORMONE IMPLANTS ON FATTENING LAMBS. R. H. Hatch*, J. K. Matsushima, C. H. Adams and H. K. Urman, *University of Nebraska, Lincoln.*

Thirty-nine western wether lambs were included in a test to determine the effects of thyroxine and testosterone implants, singly and in combination, on feedlot performance, digestibility of nutrients, nitrogen retention, carcass evaluation and wool growth. Twenty-four of the lambs were fed for 109 days, 7 for 30 days and 8 for 60 days and then slaughtered. The lambs were allotted to four treatments: (1) Subcutaneous injection of 5 mg. sodium-L-thyroxine; (2) subcutaneous injection of 25 mg. testosterone enanthate; (3) combination of 5 mg. thyroxine and 25 mg. testosterone and (4) control. The fattening ration consisted of ground shelled corn and chopped alfalfa in equal proportions. Neither liveweight gains nor feed efficiency during the 109-day feeding trial were increased by the hormone treatments. Carcass grades were improved slightly by the thyroxine treatment. There was no difference in percent of wholesale cuts based on chilled weight. Two digestion trials, 16 and 76 days post-implant, were conducted. In Trial 1, fiber and energy digestibility and nitrogen retention were greatest in the thyroxine implanted group. Dry matter, protein and N.F.E. digestibility were greatest in the combination group. In Trial 2, however, nitrogen retention and dry matter digestibilities were greatest in the control group. The largest and smallest thyroid glands (1.66 gm. and 11.48 gm.) were taken from lambs slaughtered 30 days post-implant. However, there was no relation between size of thyroid and treatment groups for all lambs. Pelt weights averaged slightly higher in thyroxine and testosterone implanted lambs at time of slaughter. Wool measurements indicated no increase in fiber length or diameter. However there was a tendency for the combination group to have less wool grease and fiber length.

142. EFFECT OF PHYSICAL FORM OF CORN ON CATTLE RESPONSE. J. F. Hentges, Jr.*, Marco Cabezas, A. Z. Palmer and J. W. Carpenter, *University of Florida, Gainesville.*

Three physical forms of yellow corn—ground, cracked and steamed rolled (flaked)—made up 80% of four high-concentrate mixtures fed during a 112-day trial to four lots of 20 yearling steers, 10 Hereford and 10 Braham x Hereford. One mixture with ground corn was steam pelleted. Concentrates were self-fed and grass hay was offered *ad libitum*. Daily gain on cracked corn was 3.0 lb./day, 0.3 lb. less than other lots. Daily intakes (moisture-free) of concentrate and hay were, respectively: ground 23.3, 4.3; cracked 23.6, 3.5; flaked 22.5, 2.7; and pelleted 21.4, 3.8. Feed efficiency (lb. moisture-free ration/lb. gain) was: ground 8.3, cracked 9.0, flaked 7.5 and pelleted 7.7. Carcass differences between diets were not significant; however, higher average grade, more interior fat and deeper fat rind was recorded for ground and pelleted diets. Breed differences in gain, feed intake and efficiency were not significant but "estimated cutability" and carcass grades were higher ($P<0.01$) for Herefords. Rumen fluid was sampled periodically by fistula and stomach tube in eight additional steers fed the test diets. Significant differences ($P<0.01$) in total volatile fatty acids were recorded between diets and between sampling methods. Expected increase of propionic acid on flaked corn diets was observed only at 8 hours after feeding.

143. INFLUENCE OF PROTEIN, METHIONINE, AND LYSINE ON PERFORMANCE OF EARLY WEANED LAMBS. F. C. Hinds*, M. E. Mansfield, J. M. Lewis, *University of Illinois, Dixon Springs Experiment Station, Robbs.*

This study was conducted to determine the response in gain and feed to gain ratio of lambs weaned at about nine weeks of age to three levels of protein (11.62, 15.62 and 19.62 calculated crude protein). The response of lambs to lysine (3 gm. per head per day), methionine (added to supply 0.50% of the diet as methionine) and a combination of the foregoing in a diet containing 15.62% crude protein was also studied. Seventy-two lambs were divided into six lots of 12 lambs, each containing equal numbers of singles and twins. The rations

were self-fed in the pelleted form and the lambs were confined to drylot with water, salt and minerals available at all times. The data suggest a negative relationship between level of protein and gain or feed to gain ratio. At the levels studied, lysine or methionine singly did not improve lamb performance. However, with lysine and methionine in combination, a slight improvement in gain and feed to gain ratio was noticed. With the exception of lambs on the diet containing methionine, there was no marked difference in the live market grade of the lambs. The lambs on the methionine diet graded slightly lower than the other lambs. As indicated by fecal egg counts and hematocrit values, internal parasites were no problem.

144. SPIRAMYCIN AND SPIRAMYCIN COMBINATIONS IN SWINE RATIONS. J. A. Hoefer*, B. G. Harmon, and R. W. Luecke, *Michigan State University, East Lansing.*

A total of 186 pigs were used in four trials to investigate the effects of feeding spiramycin at several levels and in various combinations to weanling pigs. The control ration for all trials contained corn, soybean meal, meat and bone scrap, fish meal and alfalfa meal plus added minerals and vitamins. Trials I, II and IV were from weaning to market weight whereas Trial III was terminated at 100 lb. The experimental treatments, daily gain and feed per lb. of gain, respectively, for the four trials were as follows: TRIAL I—control, 1.54, 3.50; (2) chlortetracycline 10 gm. per ton, 1.52, 3.56; (3) spiramycin 10 gm./ton, 1.59, 3.36; (4) spiramycin 15 gm./ton, 1.63, 3.44; (5) spiramycin 20 gm./ton, 1.56, 3.41. TRIAL II—(1) control, 1.53, 3.31; (2) chlortetracycline 10 gm./ton, 1.48, 3.21; (3) spiramycin 10 gm./ton, 1.52, 3.30; (4) spiramycin 15 gm./ton, 1.56, 3.26; (5) spiramycin 20 gm./ton, 1.64, 3.25. TRIAL III—(1) control, 1.36, 2.62; (2) spiramycin 15 gm./ton, 1.51, 2.50; (3) chlortetracycline, 15 gm./ton, 1.44, 2.57; (4) spiramycin 7.5 + chlortetracycline 7.5 gm./ton, 1.66, 2.51; (5) oxytetracycline 15 gm./ton, 1.54, 2.52; (6) spiramycin 7.5 + oxytetracycline 7.5 gm./ton, 1.48, 2.54. TRIAL IV—(1) control, 1.56, 3.45; (2) spiramycin 15 gm./ton, 1.62, 3.44; (3) spiramycin embonate 15 gm./ton, 1.62, 3.39; (4) spiramycin embonate 22 gm./ton, 1.60, 3.43.

145. DIETARY NITRITE vs. SHEEP PERFORMANCE. W. O. Holst*, L. M. Flynn, G. B. Garner, and W. H. Pfander, *University of Missouri, Columbia.*

Wether lambs were fed a ration containing cottonseed hulls and supplements similar to those described by Pfander and Verma (1957). After 2 months the ration was changed to corn cobs, wheat bran, soybean meal, barley, and minerals. Sub treatments included four sheep receiving supplemental vitamin D plus nitrite; four vitamins A and D plus nitrite; two vitamins A and D. Within each treatment two animals received 3% added vegetable oil. Nitrite additions were in the form of equal molar mixtures of sodium and potassium nitrite. Levels varied from 0.1% initially to 0.75% for the final month. It was impossible to prevent the loss of an undetermined amount of nitrite between the time it was added to the feed and the feed was consumed by the sheep. No increase in methemoglobin was observed at any time on this test. Rumen microorganisms from these sheep reduced 80% of the nitrite within 15 minutes. There was no evidence of vitamin E deficiency as measured by hemolysis time. Liver vitamin A was low in those animals fed nitrite. *In vivo* and *in vitro* observations indicate that nitrite added to the blood was effective in causing methemoglobin.

146.

147. CONTRASTING RESPONSES OF LAMBS TO SELENIUM AND VITAMIN E ON NATURAL AND SEMI-PURIFIED DYSTROPHOGENIC RATIONS. L. L. Hopkins, Jr.*, A. L. Pope and C. A. Baumann, *University of Wisconsin, Madison.*

Nineteen infant lambs consuming artificial milk containing torula yeast developed nutritional muscular dystrophy. The clinical symptoms were prevented in treated lambs by either selenium and/or vitamin E; however, for complete prevention or cure vitamin E appeared essential. Diagnosis was confirmed by serum glutamic oxalacetic transaminase measurements, histological examination, and clinical observations. In another experiment selenium and/or vitamin E were given to lambs nursing ewes consuming dystrophogenic hay and similar results were obtained. Vitamin E supplementation resulted in normal transaminase values (200 units) throughout a thirteen week experiment. The group given selenium exhibited normal transaminase averages through the fifth week, but became abnormal thereafter. The peak averages were 888 and 992 units/ml. at the seventh and tenth weeks, respectively. Ten lambs receiving no supplementation had average transaminase values over 200 units by the third week, and reached a peak of 1960 units by the fifth week. Stiffness was noted in the lambs during the peak transaminase period although no lamb was immobilized due to dystrophy. Selenium given to one-half of these dystrophic lambs at the seventh week reduced the transaminase levels from an average of 1000 units to 518 units one week later but beyond this there was no further drop. No drop was evidenced in the untreated lambs. Similarly, dystrophic lambs consuming artificial milk showed an initial transaminase drop due to selenium therapy but subsequently the values rose comparably to those receiving selenium throughout the exepriment. In all experiments selenium supplemented lambs grew consistently better than those not given selenium.

148. NUTRITIVE VALUE OF RAW OR HEATED UNEXTRACTED SOYBEANS AS SUPPLEMENTAL PROTEIN FOR SWINE. A. A. Jimenez*, T. W. Perry and W. M. Beeson, *Purdue University, Lafayette, Indiana.*

Thirty-six crossbred weanling pigs were fed the following rations: corn-soybean oil meal (control); corn-soybean oil meal plus soybean oil (oil control); corn-heated soybeans; corn-heated soybeans plus chlortetracycline (CTC); corn-raw soybeans; and corn-raw soybeans plus CTC. All diets were supplemented with 0.25% DL-methionine and were fed at the 16% crude protein level until pigs reached 100 lb.; thereafter, the protein level was dropped to 13%. The average daily gains and feed efficiency, respectivly, were as follows: control 1.70–356; oil control 1.73–298; heated soybeans 1.85–309; heated soybeans + CTC 1.89–307; raw soybeans 1.26–398;

raw soybeans plus CTC 1.33–418. Standard carcass measurements were taken from all pigs. Carcasses from hogs fed soybean oil meal yielded higher percentage of lean cuts than those from lots fed unextracted soybeans. The average backfat thicknesses (in.) for each group, respectively, were 1.64, 1.67, 1.70, 1.73, 1.77, and 1.64. The iodine number and the refractive index were definitely lower in the lards obtained from hogs fed the control ration. The consistency of the lard measured by a viscosimeter and expressed in centipoises also indicated harder fat for this group within a wide range of temperatures considered. The improvement in gain by CTC appeared to be greater in the raw soybean diet than in the heated soybean diet.

149. COMPARISON OF TDN AND DE FOR EVALUATING FEEDSTUFFS. R. E. John*, D. Richardson, and W. S. Tsien, *Kansas State University, Manhattan.*

Eight Hereford steers were fed four different rations in an experiment designed as a 4 x 4 latin square. The rations consisted of three parts concentrates and one part roughage in which sorghum silage, alfalfa hay and soybean oil meal were common to all rations. The grain was either cracked, finely ground or pelleted sorghum grain or cracked corn. Nine lambs were selected and divided into three groups and fed three rations of 65% alfalfa and 35% corn. Rations 1 and 2 were pelleted with ration 1 containing dehydrated alfalfa and ration 2 sun-cured alfalfa. Ration 3 was not pelleted. All lambs received all rations. The kind of grain and method of preparation influenced percentages of TDN and DE in the steer rations; however, the correlation values between the two methods were high (0.972 to 0.997). Average Calories per pound of TDN for the four rations was 2004. The kind of ingredients and method of preparation also influenced percentages of TDN and DE in the sheep rations. Again the correlation between the two measurements were high (0.962 to 0.997). Average Calories per pound of TDN was 1975.

150. CHLORTETRACYCLINE-SULFAMETHAZINE-PENICILLIN COMBINATION FOR EARLY-WEANED PIGS. D. D. Johnson*, R. F. Elliott, J. J. Drain, and R. G. Brown, *American Cyanamid Company, Princeton, New Jersey.*

Four experiments involving 323 pigs were conducted to evaluate this combination of antibacterial agents in starter diets of pigs under above-average farm conditions. The pigs were weaned at approximately three weeks of age and started on experiment immediately after uniform distribution into four treatment groups: I. Control; II. Chlortetracycline, 100 gm./ton; III. Chlortetracycline, 100 gm. per ton and Sulfamethazine, 100 gm./ton; IV. Chlortetracycline, 100 gm./ton, Sulfamethazine, 100 gm./ton and Procaine Penicillin, 49 gm./ton. Body weights and feed weights were taken at two-week intervals. The average daily gains, feed intake and feed conversion in pounds, respectively, for the six-week period were: I. 0.48, 1.05, 2.16; II. 0.68, 1.32, 1.93; III. 0.78, 1.47, 1.88; IV. 0.88, 1.69, 1.92. The standard error of the differences for average daily gains among the following comparison groups was ±0.03 lb. (I. vs. II., II. vs. III., and III. vs. IV.). Significant differences were detected in each comparison ($P<.02$).

151. COMPARISON OF THREE TYLOSIN FEEDING REGIMES FOR GROWING-FINISHING SWINE. C. E. Jordan*, W. P. Waitt, T. M. Means, F. R. Carter and C. E. Redman, *Eli Lilly and Company, Greenfield, Laboratories, Greenfield, Indiana.*

Two groups of 300 pigs each (29 and 32 lb. averages) were equally divided into 10 lots within each outcome group. Five treatments were randomly assigned within the 10 pens, resulting in two replicates of 30 pigs in each outcome group or a total of four replicates per treatment. Pigs were individually removed as they reached a market range of 195 to 205 lb. Treatments and levels of antibiotic per ton of complete feed from initial weight to 40 lb., 40 to 100 lb., and 100 lb. to market weight were: 1) basal ration; 2) penicillin-streptomycin combination (1:3), 40–20–10 gm.; 3) tylosin, 80–40–20 gm.; 4) tylosin, 40–20–10 gm.; and 5) tylosin, 20–10–5 gm. Two replicates of each treatment were fed Hygromix (anthelmintic antibiotic) to approximately 100 lb. Average daily gains (lb.) and feed per lb. of gain (lb.) from 30 to 40 lb.) were: 1) 0.78, 2.53; 2) 0.87*, 2.34; 3) 1.00**, 2.15**; 4) 0.97**, 2.22*; and 5) 0.95**, 2.22*. ADG and F/G from 30 to 100 lb. were: 1) 0.97, 2.94; 2) 1.05, 2.86; 3) 1.24**, 2.78; 4) 1.21**, 2.84; and 5) 1.15**, 2.80. ADG, F/G and average days on feed from 30 to 200 lb. were: 1) 1.29, 3.21, 127; 2) 1.33, 3.18, 126; 3) 1.43**, 3.14, 120; 4) 1.42**, 3.19, 120; and 5) 1.38*, 3.15, 122 (**$P<0.01$ and *$P<0.05$). All three tylosin feeding regimes significantly increased growth rate with a trend toward increased feed efficiency. Hygromix did not interfere with the growth response of the other antibiotic treatments.

152. VITAMIN A STATUS OF STEERS FED "HIGH NITRATE" CORN SILAGES, AND A STUDY OF SUBSEQUENT EFFECTS UPON CAROTENE UTILIZATION. H. A. Jordan*, A. L. Neumann, G. S. Smith, J. E. Zimmerman, and R. J. Vatthauer, *University of Illinois, Urbana.*

Silages were made from four fields of corn grown under conditions of varied soil nitrogen fertility and varied seeding rates. Silage contents of nitrate (percent KNO_3 equivalent, dry basis) and of carotene (mg. per lb., fresh basis) were: (I) 0.16, 2; (II) 0.18, 5; (III) 0.75, 8; and, (IV) 0.63, 8. The silages were full-fed to 48 steers averaging 500 pounds body weight, and allocated randomly into four lots. During the 133-day feeding period starting November 2, 1960, average daily gains for steers in the four lots were: (I) 1.13, (II) 1.33, (III) 1.24, and, (IV) 1.40 pounds. Initially, plasma and liver (biopsy sample) contents of Vitamin A were 35 mcg. per 100 ml. plasma and 30 mcg. per gm. fresh liver. After 88 days, liver contents of Vitamin A had decreased to the following values (lot means ± standard deviations): (I) 17.6±8.5; (II) 16.0±9.3; (III) 7.6±2.8; and, (IV) 5.7±4.3. After 133 days, liver contents of Vitamin A were equally low in all lots, averaging 3.0 mcg. per gm. of fresh liver. Plasma contents of Vitamin A, averaged 30 mcg. per 100

ml. In March all steers were moved onto a ration of mixed hay, soybean meal, and a full-feed of shelled corn. Sixteen steers were fed daily 8000 IU stabilized, preformed Vitamin A; 16 were fed 8000 IU Vitamin A activity (1 mg.=400 units) as stabilized, beta-carotene; and 16 were non-supplemented. Daily gains during the 98-day study averaged 2.33, 2.45, and 2.44 lb. Liver contents of Vitamin A remained low in all steers, averaging 3.3±1.4, 3.3± 1.6, and 2.3±1.4 mcg. per gm., respectively, in the three groups. Plasma values were 27±5, 27±8, and 27±6 mcg. % for the three groups.

153. EFFECT OF VIRGINIAMYCIN ON SUCKLING AND FATTENING LAMBS. R. M. Jordan*, *University of Minnesota, St. Paul.*

Two replicated experiments involving 139 fattening lambs and one replicated trial involving 77 suckling lambs were conducted to determine the effect of feeding virginiamycin on weight gains, feed efficiency, and feed consumption. *Fattening Lambs.* Average daily gains in experiment 1 were: control, 0.38 lb.; 18½ mg. virginiamycin per lamb daily, 0.41 lb. and 37 mg. virginiamycin per lamb daily, 0.45 lb. The difference in gains for the control and the virginiamycin groups is statistically significant. The difference in weight gains between the two levels of virginiamycin approaches significance at the 5% level and suggests the existence of a dose-response relationship. In experiment 2, daily weight gains per lamb were: control, 0.56 lb. and 20 mg. of virginiamycin per lamb daily, 0.59 lb. This difference is not significant. Feed consumption and feed efficiency were not affected by treatment. *Suckling Lambs.* Three-week old lambs weighing approximately 20 lb. each were self-fed a complete pelleted ration containing 25% alfalfa hay, 15% soybean meal, 10% wheat bran, 48½% ground shelled corn, 1% trace mineralized salt, and 1% limestone. The treated lambs received 20.8 mg. virginiamycin per lb. of ration. Average daily gains were: control, 0.81 lb. and treated, 0.84 lb. per lamb. Differences in rate of gain are not significantly different. Three lambs in the treated group and one lamb in the control group were removed due to urinary calculi.

154. COMPARISON OF DIFFERENT SILAGES WITH AND WITHOUT IMPLANTS FOR FATTENING CATTLE. Wendell Kent*, Dallas Powell, Ralph M. Durham and Frank Hudson, *Texas Technological College, Lubbock.*

Three varieties of silage were tested in combination with implanting 12.mg. stilbestrol vs. non-implanting. Corn silage, Red Top Cane and Sart sorghum were used in the trial which included 32 animals on each silage. Forty-eight animals were implanted, and 48 were not implanted. Feedlot performance significantly favored Corn silage over the two sorghum silages, and Red Top Cane over Sart. All lots were fed a constant level, hence the differences in gain were a direct measure of feed conversion. There were no silage effects on carcass merit. Implanting had a small but significant gain effect. However, implanting produced some substantial carcass differences. Implanted steers had significantly less marbling and a sharply reduced U.S.D.A. grade. However, they had significantly greater cutout and a slight but non-significant tenderness advantage over non-implanted steers.

155. VALUE OF MENHADEN FISH MEAL AS A PROTEIN SUPPLEMENT TO PRACTICAL SWINE DIETS. I. CORN-SOYBEAN DIETS. Robert R. Kifer * and Edgar P. Young, *Bureau of Commercial Fisheries and University of Maryland, College Park.*

Two feeding trials (summer and winter) were conducted to evaluate menhaden fish meal as a protein supplement to swine diets, and to determine the total dietary crude protein level required for swine. Animals averaging 55±2 lb. per group, were allotted to each of five treatment groups in both trials. Diets fed to the animals during the summer trial contained corn-soybean meal, with and without fish meal, at two initial levels of total crude protein (16 and 14%). Fish meal was added to the diets in both trials to replace a portion of the soybean meal. Statistical analysis of results of the summer trial indicated no difference in rates of gain, and utilization of feed or carcass measurements (backfat thickness, length of carcass and leg, and lean cut yield) related to dietary treatments. Also, no differences in organoleptic evaluation for flavor, odor, and texture were detected in cooked loins from test animals. Diets fed to the animals during the winter trial contained corn-soybean meal, with and without fish meal, at three initial levels of total crude protein (16, 15, and 14%). Statistical analysis of results obtained, indicated no differences in rates of gain or carcass measurements. However, a difference in feed utilization between lots was observed in this trial. Data from both trials indicate that dietary levels of total crude protein above 14% with and without fish meal were in excess of the pig's requirement.

156. LEVELS OF NUTRITION AND BEEF CARCASS COMPOSITION. Earle W. Klosterman*, Paul Althouse and Vern R. Cahill, *Ohio Agricultural Experiment Station, Wooster.*

A 23 factorial experiment with two rations, a full feed of corn silage (S) or a full feed of ground ear corn (c) and three periods, 112, 84 and 56 days, successively, was conducted. Thus, the eight treatments were SSS (silage in all three periods), CSS, SCC, CCC, SSC, CSC, SCS and CCS. Hereford steers which averaged 474 lb. initially were fed. Weighted average daily gains for the total 252 days were: SSS, 1.56; CSS, 1.89; SCC, 2.01; CCC, 2.23; SSC, 1.72; CSC, 1.99; SCS, 1.86; and CCS, 2.15 lb. Three steers from each treatment were slaughtered at the end of each period for detailed slaughter and carcass studies. Data collected included overnight shrink off feed and water, dressing percent, carcass grade, bone, fat trim, edible portion and ether extract of *longissimus dorsi* muscle. Feed requirements were converted to therms of estimated net energy. The therms of estimated net energy required per pound of liveweight gain and per pound of edible portion gain at the end of the second period were; SS, 4.2 and 10.1; CS, 4.6 and 10.7; SC, 4.4 and 10.4; CC, 4.7 and 10.4, respectively. Similar data were calculated at the end of the third period. A second experiment was conducted with two rations, a full feed of pelleted alfalfa or a full feed of ground

ear corn and two periods. In this experiment all lots of cattle were fed to the same final weight.

157. LINSEED OIL MEAL AND LYSINE FOR CATTLE FED HIGH-CORN SILAGE RATIONS. O. E. Kolari, A. L. Harvey, J. C. Meiske and W. J. Aunan, *University of Minnesota, St. Paul.*

Two trials were completed in which 4 levels of linseed oil meal (LOM) were fed to cattle in drylot: (1) 1.5; (2) 2.0; (3) 2.5; and (4) 3.0 lb. Two lots each of 8 cattle were fed each level of LOM in each trial. Lysine was fed at 10 grams per head daily to one lot of cattle within each LOM level. Sixty-four yearling steers (starting weight, 812 lb.) were fed in trial 1 and 64 heifers (starting weight, 482 lb.) were fed in trial 2 for 89 and 118 days, respectively. Corn silage was fed to appetite. The combined daily TDN intake from ground ear corn and LOM between LOM levels was equalized by varying the amount of ear corn fed. An average of about 6 lb. ground ear corn per head daily was fed. Average daily gains and feed dry matter required per 100 lb. gain (lb.) for the 4 LOM levels were: (1) 1.5 lb. LOM, 2.64, 727; (2) 2 lb. LSM, 2.58, 772; (3) 2.5 lb. LSM, 2.69, 741; (4) 3 lb. LSM, 2.59, 768. Similar data for the heifers, in the order listed above, were respectively: (1) 1.83, 715; (2) 2.05, 667; (3) 2.02, 673; (4) 1.96, 683. Results of these trials indicated that 1.5 lb. LOM feed per head daily provided adequate protein for heavyweight yearling steers but was marginal for heifers in meeting the protein needs of cattle fed high-corn silage, restricted-grain rations. No benefit was obtained from feeding lysine.

158. VITAMIN A STUDIES WITH FEEDER CATTLE. O. E. Kolari, A. L. Harvey, M. E. Davison, J. C. Meiske and W. J. Aunan, *University of Minnesota, St. Paul.*

Three experiments were conducted in which 100,000 units of vitamin A were fed for 5 days to feeder cattle in drylot to one-half of a group of: (1) 46 heifers at the start of a 106-day trial; (2) 46 heifers at the start of a 116-day trial and again after 62 days; (3) 32 yearling steers at the start of a 153-day trial and again after 71 days. Average daily gains and feed required per 100 lb. gain (in pounds) for the above trials in the order listed were, respectively: (1) control, 1.76, 745; vitamin A, 1.84, 721; (2) control, 2.05, 1009; vitamin A, 2.04, 1000; (3) control, 2.41, 863; vitamin A, 2.40, 852. Blood plasma vitamin A was determined on six heifers and 17 steers from (2) and (3) above after being on feed for 98 and 107 days, respectively. Vitamin A values (mcg. percent) for the heifers were: control, 35; vitamin A supplemented, 37. Treatments and plasma vitamin A values (mcg. percent) for the control and vitamin A supplemented steers were, respectively: ear corn and hay, 37, 50; ear corn and no hay, 24, 33; shelled corn and hay, 22, 41. After the steers were slaughtered, liver carotenoid and vitamin A values (mcg. percent) determined for the various treatments were, respectively: ear corn and hay, 21.7, 45.5; ear corn only, 6.8, 3.3; and, shelled corn and hay, 16.0, 25.5. Some steers fed ear corn and no hay showed clinical symptoms of vitamin A deficiency.

159. METHIONINE REQUIREMENT OF THE SUCKLING AGE PIG. G. H. Kroening*, W. G. Pond and J. K. Loosli, *Cornell University, Ithaca, New York.*

Growth and N-balance studies were conducted with suckling age pigs. In the growth study twenty-three 10-day old pigs weighing an average of 8.3 lb. initially were used. Either isolated soy protein, casein, or soybean meal was added to purified ingredients as the sole source of protein. All rations contained 12% protein and were fed *ad libitum*. The calculated methionine-cystine content (% of ration), daily gain, feed per lb. of gain and average daily feed intake for 28 days were: (1) isolated soy protein (basal), 0.19, 0.46, 2.59, 1.19; (2) basal plus 0.23% DL-methionine, 0.42, 0.58, 2.06, 1.18; (3) basal plus 0.46% DL-methionine, 0.65, 0.54, 2.08, 1.13; (4) casein, 0.41, 0.61, 1.91, 1.16; (5) soybean meal, 0.34, 0.67, 2.03, 1.36. The average daily gain for Lot 1 was significantly lower than that of all other lots. Nitrogen balance studies with 16 3-week old pigs were conducted using 7-day preliminary and 5-day collection periods. Apparent digestibility of nitrogen (%) and apparently digested nitrogen retained (%) were: (1) isolated soy protein (basal), 92.1, 63.1; (2) basal plus 0.23% DL-methionine, 92.9, 72.4; (3) basal plus 0.46% DL-methionine, 93.2, 72.9; (4) soybean meal, 88.3, 66.9. The apparent nitrogen digestibility of the soybean meal was significantly lower than all other lots. The apparently digested nitrogen retained by Lots 2 and 3 was significantly higher than Lots 1 and 4. The soybean meal ration contained a calculated 0.34% methionine-cystine (2.8% of protein). Pigs fed isolated soy protein rations supplemented to contain 0.42% methionine-cystine (3.5% of protein) performed as well in every respect as those fed the 0.65% level (5.4% of protein).

160. EFFECT OF THYROXINE ADMINISTRATION ON MILK PRODUCTION AND WEIGHT GAINS OF RANGE BEEF CATTLE. L. R. Kuhlman*, R. D. Furr and A. B. Nelson, *Oklahoma State University, Stillwater.*

Thirty-two, fall-calving, grade Hereford cows were divided into two groups on the basis of body weight, stage of lactation, and average milk yield on five previous monthly collections. One group was implanted with six 30 mg. pellets of sodium-L-thyroxine on June 10. The 24-hour milk yield of the cows was estimated at 2-week intervals by weighing the calf before and after nursing. Milk production of the implanted group two weeks after implantation was increased 17% over the previous collection period (6.76 vs. 7.94 lb.) while the milk yield of the non-implanted group declined slightly (6.48 vs. 6.31 lb.). Milk yields for the next two intervals were 5.79 and 5.11 lb. respectively, for the implanted group and 5.90 and 6.25 lb. for the controls. Average cow weight gains were considerably less for the implanted group for the first month but were the same thereafter. Calves which suckled the implanted cows gained slightly more than the calves whose dams were not implanted. In another test, 30 spring-dropped calves weighing about 260 lb. were divided into 3 lots on July 16 on the basis of weight and sex. Those in Lot 1 served as controls, Lot 2 was implanted with two 30 mg. pellets of sodium-L-thyroxine and Lot 3 was injected with 1 cc of oil containing 100 mg. of sodium-L-thyrox-

ine. Average daily gains in the first 31 days were 1.77, 1.71 and 1.10 for Lots 1, 2 and 3, respectively. At this time a second dosage was administered and the average daily gains for the next 28-day period were 1.54, 1.14 and .82 lb. No additional thyroxine was administered and average daily gains for the final 29-day period were 1.52, 1.83 and 2.07 lb.

161. RELATIONSHIP OF SERUM MAGNESIUM, CALCIUM AND PHOSPHORUS TO INCIDENCE OF URINARY CALCULI IN LAMBS. H. O. Kunkel*, Earl S. Whitaker, Leonard V. Packett, Jr., and H. R. Crookshank, *A. & M. College of Texas, College Station. A.R.S., U.S.D.A.*

Magnesium, calcium and orthophosphate were determined in sera from lambs which survived a 98-day feeding experiment in which 36 of 218 lambs died with renal and cystic phosphatic calculi. Kidneys from 153 lambs were examined for macroscopic and histopathologic evidence of incipient urolithiasis. Seventy-six percent of these lambs had calculi in the collecting tubules, in the renal pelvis or in both sites. The product-moment coefficient of correlation of serum Mg to the quantal incidence of calcului was significant ($r=0.17$, $p<0.05$). Grouping data within class intervals of 0.4 mg. Mg per 100 ml. serum yielded these percentages of incidence: 1.0–1.4 mg., 56% (5) of 9 lambs had calculi; 1.5–1.8 mg., 69% (9) of 13; 1.9–2.2 mg., 73% (24) of 33; 2.3–2.6 mg., 77% (39) of 51; 2.7–3.0 mg., 79% (19) of 24; 3.1–3.5 mg., 91% (21) of 23. Probit analysis yielded a probit regression and an expected incidence within each class interval of Mg concentration from which the deviations of observed incidences were small (probit $\chi^2=1.02$, d.f.=5, $p>0.95$), thus suggesting that incipience of calculi was related to level of blood Mg. Serum Ca and P were not directly related to the incidence of calculi. But, among the lambs with incipient urolithiases, the proportion of pelvic calculi was significantly greater ($p<0.01$) in animals with the wider Ca:P ratios in the serum. It is suggested that the incipience of urinary calculi has an explanation in metabolic as well as nutritional terms.

162. EFFECT OF SODIUM BICARBONATE ON RUMEN MICROBIAL ACTIVITY. J. W. Lassiter*, Prasob Buranamanas and M. K. Hamdy, *University of Georgia, Athens.*

The effect of sodium bicarbonate on the microbial flora, pH, and volatile fatty acid content of the rumen was studied in fistulated steers fed a pelleted ration. Highly significant regressions of anaerobic populations and acetic, propionic, butyric and valeric acid concentrations on $NaHCO_3$ consumption and on time were observed. No regression of counts with water or feed consumption were found, but significant negative regressions of the concentrations of acetic, butyric and valeric acids, and the sum of these plus propionic acid upon water consumption were shown.

163. EFFECT OF SODIUM BICARBONATE ON NUTRIENT DIGESTIBILITY OF A PELLETED RATION BY STEERS. J. W. Lassiter* and M. K. Cook, *University of Georgia, Athens.*

Six yearling Angus steers were used in two trials to study the effect of $NaHCO_3$ upon nutrient digestibilities of a pelleted complete ration. Each trial consisted of a double reversal experimental design with three comparison periods and two treatments. Treatment 1 consisted of the pelleted ration and untreated drinking water, while treatment 2 was composed of the same ration with 2.27 grams of $NaHCO_3$ per pound of water (0.5%). In trial 1, *ad libitum* feeding was employed whereas controlled feeding was used in trial 2. There were no statistically significant differences in digestibility due to treatment in either trial. In trial 2, the effect of $NaHCO_3$ on the digestion coefficient for ether extract approached significance and there was a tendency for $NaHCO_3$ to affect the digestibility of the dry matter. There was no significant difference in feed intake in trial 1 due to treatment, but there was a significant difference ($P<0.05$) in water intake due to $NaHCO_3$ addition.

164. IRON REQUIREMENT OF GROWING-FATTENING LAMBS FED SEMI-PURIFIED DIETS. M. J. Lawlor, W. H. Smith* and W. M. Beeson, *Purdue University, Lafayette, Indiana.*

Two experiments involving 18 lambs were conducted to further determine the Fe requirement. In experiment I, 12 lambs averaging 30.0 lb. were fed a semi-purified diet composed of finely ground corn cobs, dried skimmilk, starch, cerelose, corn oil, vitamins and minerals. Dietary levels of 25, 40 and 70 ppm Fe were compared. Six lambs were used in experiment II, and Solka-Floc replaced corn cobs as the roughage source. Dietary levels of 25 and 70 ppm Fe were first compared; and after a 49-day period, a dietary level of 10 ppm Fe replaced the 25 ppm Fe. The response criteria used in determining the Fe requirement were (a) general appearance, (b) growth rate, (c) R B C count, (d) gains of the lambs on experiment I receiving 25, Hb, (e) cell volume and (f) serum Fe. The daily gains of the lambs on experiment I receiving 25, 40 and 70 ppm Fe were 0.42, 0.57 and 0.63 lb., respectively. The daily gains of those receiving 25 and 70 ppm Fe in experiment II were 0.45 and 0.36 lb., respectively. When these lambs were changed to dietary levels of 10 and 70 ppm Fe, their daily gains were —.07 and 0.57 lb., respectively. Iron deficiency symptoms including anorexia, emaciation and pale appearance were observed with the lambs receiving 10 ppm Fe. In a 28-day repletion study, the iron-deficient lambs when fed 70 ppm Fe maintained a daily gain of 0.71 lb. No hematological changes were observed among the lambs on any of the Fe treatments. There was a significant difference ($P<.01$) between the growth rate of the lambs receiving 25 ppm and those receiving either 40 or 70 ppm Fe. The minimum Fe requirement of growing lambs would seem to be between 25 and 40 ppm.

165. CRITERIA FOR MEASURING MOLYBDENUM TOXICITY. A. L. Lesperance* and V. R. Bohman, *University of Nevada, Reno.*

Thirty-two weanling heifers were randomly allotted to the following treatments: alfalfa; alfalfa and molybdenum (100 ppm of ration); grass and cottonseed meal; grass, cottonseed meal, and molybdenum (100 ppm) for a one year period. Animals were fed hay *ad lib.*, with protein equalized. Molybdenum intake was adjusted weekly. Twenty-nine

different criteria were evaluated periodically during the trial. Plasma molybdenum increased approximately 100-fold during the first 30 days but was relatively constant thereafter. Both alfalfa and molybdenum generally increased plasma copper. Plasma phosphorus and hematocrit showed no consistent trends. Liver molybdenum gradually increased during the study. Liver copper increased from seven to twenty-six ppm when alfalfa was fed but remained at four to seven ppm for the other three treatments. Liver iron content was not altered by treatment. Dietary molybdenum increased bone molybdenum. Alfalfa elevated the ash and calcium content of bone samples, however, bone phosphorus was not affected by the treatments. Molybdenum caused typical symptoms of achromotrichia and scouring. Control animals gained approximately one-half pound more, and consumed significantly more forage, daily, than those receiving molybdenum. Molybdenum decreased energy balances but had no effect on nutrient digestibility or copper, phosphorus, sulfur or nitrogen balances. Animals fed molybdenum stored approximately 100 mg. molybdenum daily. From these data it would appear that plasma molybdenum is the best immediate criteria of excess molybdenum intake, but over a long period of time, liver molybdenum is more indicative of toxicity.

166. EFFECTS OF DIETARY MANGANESE ON BABY PIG PERFORMANCE AND TISSUE MANGANESE LEVELS. J. Liebholz*, V. C. Speer, J. T. McCall and V. W. Hays, *Iowa State University, Ames.*

Three experiments involving a total of 84 individually-fed pigs and 72 group-fed pigs (three per pen) were conducted to investigate the influence of various manganese levels in semi-purified and natural rations on the performance of pigs. Manganese levels were as low as 0.35 ppm in the semipurified diet and in no case was there a growth depression or was the utilization of feed adversely affected when compared to performance on the same diet supplemented with 40 ppm Mn. The alkaline phosphatase activity and the manganese content of the surgically removed metatarsal bones were reduced by the low dietary Mn intakes. There was no effect on ash or fat content of bone or the alkaline phosphatase activity of the serum, kidney and liver. Increased Mn intake significantly increased Mn level in the liver but not in the kidney, spleen or loin. There was no effect on liver arginase activity. Natural rations were supplemented with 0, 40, 400 and 4000 ppm Mn as the inorganic salt in one trail and with 0, 25, 75, 225, 675 and 2025 ppm in another trial. The pigs were fed for a 6- or 12-week period and in no case was there a growth response to the Mn supplementation or a growth retardation resulting from the high Mn levels. Increased Mn intake resulted in increased Mn in the bone and hair. There were no differences in bone ash, bone fat or hemoglobin levels.

167. FURTHER STUDIES WITH ELECTRONICALLY COMPUTED PIG RATIONS. L. E. Lloyd*, E. W. Crampton, and R. A. Costain, *Macdonald College (McGill University), Quebec, Canada.*

In an earlier study, the use of an electronically computed least cost early-weaning pig ration (Computed Ration No. 1) resulted in essentially equal growth rate, improved feed efficiency but significantly reduced feed intake when compared to a nutritionally proven control ration. The present report compares the performance of 96 early-weaned pigs fed individually in a comparative feeding and digestibility trial for a 6-week period on the original control ration and three modified electronically computed rations. The modifications were designed primarily to increase feed intake. Computed ration No. 2 was that used in the original study but with iodinated casein added at the level of 16 mg./kilogram of feed. Computed ration No. 3 was formulated on the basis of an increased variety of ration ingredients for electronic selection. Computed ration No. 4 was formulated on the basis of an increase in the required concentration of certain nutrients. When compared to the control, not one of the computed rations resulted in optimum feed intake and liveweight gain. Only in the case of computed ration No. 3 was feed efficiency of comparable magnitude to the control. The apparent digestibility of the dry matter, energy, crude protein and total carbohydrate tended to be greater by pigs receiving the control ration. It is suggested that the suboptimal intakes observed for each of the computed rations was due to certain non-defined physical characteristics which could not be included in the programming of the electronic computer.

168. VITAMIN A NUTRITION OF SHEEP FED HIGH-UREA RATIONS. S. B. Love*, E. E. Hatfield, G. S. Smith and U. S. Garrigus, *University of Illinois, Urbana.*

Twelve western lambs were fed a carotene-free, semipurified diet containing 4% urea as the only source of nitrogen and supplying daily 10,000 I.U. of vitamin A (preformed). After 142 days, liver contents (biopsy samples) of vitamin A averaged 68±41 mcg./gm. fresh liver. The lambs were allotted to 2 lots of 6 each and fed the following diets: diet I: semipurified diet consisting of 40% corn cobs, 25.5% starch, 2% corn oil, 10% glucose, 4% mineral mix, 12% purified soybean protein, 0.5% DL-methionine, 2.5% Ca-acetate, 2.5% Na-acetate 0.5% KCl and B-vitamins, vitamin E and antibiotics; diet II: same as diet I with the exception that urea was substituted for starch in an amount equal to 5% of the diet. Each ration was supplemented with 5,000 I.U. vitamin A, preformed. During 31 days on the diets, liver stores of vitamin A changed as follows: Lot I: 61±24 to 91±14 mcg./gm. fresh liver; Lot II: 75±25 to 78±11 mcg./gm. fresh liver. Plasma values in the two lots after 31 days were: Lot I: 30±3 mcg.% and Lot II: 36±11 mcg.% vitamin A. At the start of the 31-day feeding period, Lot I lambs averaged 90 lb. per head while Lot II lambs averaged 95 lb. per head, and at the conclusion of the period Lot I averaged 99 lb. as compared with 103 lb. for Lot II.

169. DEVELOPMENT OF A PROTEIN MALNUTRITION SYNDROME IN THE YOUNG PIG. R. S. Lowrey*, W. G. Pond, J. K. Loosli and R. H. Barnes, *Cornell University, Ithaca, New York.*

Twenty pigs averaging 13.8 lb. were allotted at random to the following treatments: (1) 5% protein (casein), 3% corn oil; (2) 5% protein (casein), 23% corn oil; (3) 5% protein (purified wheat gluten), 3% corn oil; (4) 5% protein (purified

wheat gluten), 23% corn oil; (5) fortified creep ration. All diets were fed *ad libitum*. Average daily gain (lb.) and average daily protein intake (gm.) for treatments 1–4 were 0.39, 50.8; 0.21, 28.8; 0.01, 16.1; and 0.00, 14.3, respectively. Animals on treatment 5 gained 1.41 lb. per day. Pigs on treatments 3 and 4 were emaciated, anemic and exhibited difficulty in moving about during the last 2 to 3 weeks of the 14-week experimental period. Total serum protein and serum albumin levels were depressed to approximately 4.2 and 0.7 gm. per 100 ml., respectively, after 10 weeks on trial in pigs on treatments 1–4. Adrenal, heart and liver weights, as a percentage of body weight, were greater in those animals receiving treatments 3 and 4 compared to those on the casein treatments (1 and 2). Adrenal weights were greater in the animals receiving the gluten-high energy diet (4) than in those on the gluten-low energy diet (3). Bone growth was depressed in the gluten-fed animals, and the carcasses exhibited extensive edema. Pathological changes occurred in the bone, muscle, heart, liver, hair, skin, endocrine glands, brain, spleen, stomach and intestine. The most severe changes occurred in the animals on treatment 4 followed by treatments 3, 2, and 1, respectively.

170. EFFECT OF EITHER SUPPLEMENTARY ZINC OR VITAMIN D IN SWINE RATIONS VARYING IN CALCIUM LEVEL. R. W. Luecke, E. T. Kornegay*, E. R. Miller and J. A. Hoefer, *Michigan State University, East Lansing.*

Two trials involving 108 weanling pigs were used to determine the calcium requirement for growing-finishing pigs and the relationship of added zinc and vitamin D. A fortified corn-soybean meal ration was fed *ad libitum* and levels of 0.3, 0.5, and 0.7% calcium were studied in both trials. All pigs were slaughtered when they reached market weight. Sixty pigs were used in the first trial with zero and 60 ppm zinc added to each level of calcium. The addition of zinc had no affect on any of the criteria studied. An analysis of the growth and feed consumption data indicates that 0.3 and 0.5% dietary calcium support maximum growth and feed efficiency with depression of growth rate in pigs receiving 0.7% calcium. Specific gravity and bone ash data on the 11th rib were however significantly greater for the 0.5 and 0.7% calcium than for the 0.3% calcium. Breaking strength of rib was greatest in pigs receiving 0.5% calcium. Forty-eight pigs were used in the second trial with 100 and 1000 IU of vitamin D added to each calcium level. There were no differences between levels of vitamin D with any criterion studied. An analysis of growth and feed consumption data revealed no significant differences between calcium levels. Specific gravity and maximum breaking strength of the 11th rib were significantly increased by increasing the level of calcium. Serum calcium was not affected.

171. METHODS OF ADMINISTERING ANTIBIOTICS AND MINERAL SUPPLEMENTS TO BEEF CALVES. R. M. Luther*, L. B. Embry and F. W. Whetzal, *South Dakota State College, Brookings.*

Two trials were conducted with 144 steer calves (av. lot wts. 382–427 lb.). During a 27-day adaptation phase the treatments were control and control plus 350 mg. Aureomycin with 20% and 40% protein supplements. The ration consisted of prairie hay, full-fed, and 2 lb. protein supplement fortified with minerals and vitamin A. Daily gains for control and Aureomycin were: trial I (12 steers/lot, replicated), 20% supplement, 1.02, 1.12; 40% supplement, 1.28, 1.56; trial II (12 steers/lot, not replicated), 20% supplement, 0.35, 0.38; 40% supplement, 0.34, 0.74 lb. Differences between treatments were significant ($P<.05$) in trial I, with the cattle fed the antibiotic and 40% supplement making the greatest gains in both trials. Feeding a 40% supplement increased gains significantly ($P<.01$) over the 20% supplement in trial I. The cattle were reassigned to wintering treatments (trial I, 151 days; trial II, 127 days) consisting of a control and 75 mg. Aureomycin with minerals force-fed and free choice. The ration included prairie hay, full-fed, and 2 lb. of a 30% supplement. Aureomycin was fed in the supplement to the force-fed groups and mixed in the salt to the free choice groups. There was no apparent difference between methods of mineral supplementation and the two groups were combined. Over-all comparisons of adaptation and wintering treatments, with rates of gain for: trial I (replicated) and trial II (not replicated), respectively, were: control, control, 1.25, 1.00; control, antibiotic, 1.24, 0.93; antibiotic, control, 1.21, 0.89 and antibiotic, antibiotic, 1.36, 1.06 lb. Differences in gain were significant ($P<.05$) in trial I.

172. EFFECT OF TROLENE ON THE PERFORMANCE OF BEEF CATTLE. N. D. Magruder* and J. W. Nelson, *Nutrena Mills, Incorporated, Elk River, Minnesota.*

Four trials have been conducted to determine the effects of feeding and administering as a bolus, organic phosphorus (Trolene) to beef calves and yearlings. Sixty-four Montana feeder calves which averaged 428 lb. were used in the first trial. Forty-eight calves were fed 0.68% Trolene for a 14-day conditioning period at the beginning of the trial. The other 16 calves served as controls and were fed a complete grain mixture and corn silage. At the end of the 320-day feeding period, total grub count and average daily gains were 10.2 and 2.03 lb. for controls and 0.0 and 2.15 lb. for the Trolene-treated steers. In the second and third trials a total of 208 yearling steers averaging 680 lb. (I) received Trolene in their rations fed for the first 14 days, and (II) administered as a bolus on the second day of the trial. Average daily gains at the completion of the two trials for controls and treated were: (I) 2.54 lb.; 2.94 lb. and (II) 2.29 lb.; 2.36 lb. The fourth trial involving 160 feeder calves with split 16 groups where seven per group received a Trolene bolus on the second day of the trial and three calves per group remained as controls showed little effect of Trolene on gain at the end of the 151-day feeding period. No harmful side effects of Trolene were observed in any of the trials.

173. FIXATION OF AMMONIA NITROGEN BY RUMEN MUCOSA. G. A. McLaren*, G. C. Anderson, W. G. Martin and W. K. Cooper, *West Virginia University, Morgantown.*

Although it is recognized that ammonia in the rumen in excess of that which can be used for microbial protein synthesis penetrates the rumen mucosa and passes into the blood, evidence will be presented which indicates that some of this ammonia may be utilized in the synthesis of L-gluta-

mate in the rumen mucosa. Three series of experiments were conducted with rumen mucosal homogenates (1.0 ml.) and the following reaction mixture: 0.067 M phosphate buffer at pH 7.0, 2.5 ml.; 0.1 M K malonate, 0.2 ml.; 0.5 M ammonium chloride, 0.2 ml.; 0.1 M alpha ketoglutarate, 0.2 ml.; reduced DPN (80 mcg.), 0.2 ml. In the first series of experiments C_{-14} labaled alpha ketoglutarate was added to the reaction mixture in Warburg vessels and incubated for 10 minutes at 30° C. Synthesis of C_{-14} labeled L-glutamate was demonstrated. Further evidence of ammonia fixation was obtained in the second series of experiments in which the oxidation of reduced DPN, measured spectrophotometrically, was used as the criterion for glutamic dehydrogenase activity. In the third series of experiments L-glutamate synthesis was measured in terms of carbon dioxide liberated from L-glutamate through the action of the enzyme glutamic decarboxylase. Synthesis of L-glutamate is favored by high concentration of ammonium ions, alpha ketoglutarate and reduced DPN. Limited data suggests that lambs fed high urea rations containing sufficient available carbohydrates have a greater capacity to use ammonia in the reductive amination of alpha ketoglutarate than lambs fed natural rations.

174. EFFECT OF FRACTIONS OF GRASS SILAGE ON THYROID ACTIVITY. G. A. McLaren, D. C. Crow, W. R. Lewis and I. D. Porterfield, *West Virginia University, Morgantown.*

Asplud *et al.* (J. A. S. 18:1567, 1959) reported that rats fed rations containing 20% dried grass silage (DGS) exhibited thyroid stimulation as evidenced by significant ($P<.05$) increased in both plasma protein-bound iodine and basal metabolic rate (BMR) and in the histological appearance of the thyroid gland. In the present work three experiments were conducted with male rats fed rations containing either 20% DGS, 20% ether extracted DGS, 80% ethanol extract of ether and absolute ethanol extracted DGS (equivalent to 20% DGS), 20% of residue of 80% ethanol extracted DGS and a control ration. BMR was used as a measure of thyroid activity. Rats fed rations containing 20% DGS exhibited significantly increased BMR ($P<.05$). The feeding of ether extracted DGS resulted in a significantly ($P<.05$) greater increase in thyroid stimulation than the same unextracted DGS. This suggests that ether extraction removes a thyroid inhibitor. The 80% ethanol extract of DGS significantly ($P<.05$) increased BMR over that of rats fed the control ration. 80% ethanol extraction did not remove all activity from the DGS as the residue of the 80% ethanol extracted DGS produced a significant ($P<.05$) increase in BMR. These results suggest that the stimulatory substance(s) in DGS is water soluble and may be associated with high molecular weight compounds.

175. PROTEIN DEFICIENCY AND REPRODUCTION IN THE BULL. T. N. Meacham*, T. J. Cunha, A. C. Warnick, J. F. Hentges, Jr. and R. L. Shirley, *University of Florida, Gainesville.*

Twenty-two weanling beef bulls were used in two experiments of 365 and 182 days duration. In Experiment I, four bulls were fed a control ration (14.07% protein) and six bulls a protein deficient ration containing initially 8.09 and finally 1.35% protein. In Experiment II, four bulls were assigned to the control ration (13.75% protein) and eight to the deficient ration (1.62% protein) as they reached puberty. Criteria were ADG, feed intake, semen characteristics, libido, reproductive tissue morphology, blood components and in Experiment II, a fertility test in which 208 heifers were inseminated. ADG for the control and deficient bulls in Experiment I and II were 1.63, —.17, 1.10 and —.71 lb. respectively. Feed intake was sharply reduced in the deficient groups. Semen volume and total sperm cells per ejaculate were significantly lower ($P<.05$) in the deficient groups in both experiments. Differences in sperm motility were not significant. In Experiment II, four of the eight deficient bulls died after 182 days. Three of the four bulls were producing sperm at the time of death. Final values for total sperm per ejaculate for the control and deficient groups in Experiment I and II were 2,852, 955, 1,767 and 337×106, respectively. Blood hematocrit, hemoglobin and serum protein values for the deficient groups were significantly lower ($P<.01$) than the controls. Marked morphological changes were observed in the reproductive tissues. Conception rates were apparently not affected by treatment.

176. GROWTH STIMULANTS AND ANTIBACTERIAL AGENTS FOR GROWING PIGS. H. W. Miller* and C. E. Barnhart, *University of Kentucky, Lexington.*

Three trials involving 210 early-weaned and weanling pigs were conducted to study the value of virginiamycin in swine rations. A pig starter basal ration was fed to early weaned pigs in trial 1; whereas, a corn-soybean meal basal ration was fed in trials 2 and 3. In trial 1, two lots of five pigs each were fed each ration in an enclosed heated farrowing barn. In trials 2 and 3, two lots of four pigs each were fed each ration on concrete. In trials 2 and 3, pigs were fed to a weight of 125 lb. and in trial 1, to a final weight of 50 lb. The additives per ton of ration for trial 1 were: (1) none, (2) 25 gm. virginiamycin, (3) 50 gm. virginiamycin, (4) 100 gm. virginiamycin and (5) 100 gm. aureomycin. The additives per ton of ration for trial 2 were: (1) none, (2) 50 gm. aureomycin, (3) 50 gm. aureomycin plus 1000 gm. sodium acrolate, (4) 20 gm. Pro-strep, (5) 5 gm. virginiamycin, (6) 10 gm. virginiamycin, (7) 20 gm. virginiamycin and (8) 40 gm. virginiamycin. The additives per ton of ration for trial 3 were: (1) none, (2) 20 gm. aureomycin, (3) 20 gm. aureomycin plus 1000 gm. sodium acrolate, (4) 20 gm. Pro-strep, (5) 20 gm. zinc bacitracin, (6) 20 gm. tylosin, (7) 20 gm. virginiamycin, (8) 20 gm. Terramycin, (9) 20 gm. Terramycin plus 5 gm. oleandomycin and (10) 2 lb. copper sulfate. The average daily gain (lb.) and feed per lb. of gain for trial 1 were: (1) 0.72, 2.26; (2) 0.74, 2.20; (3) 0.84, 1.89; (4) 0.91, 1.90; (5) 0.80, 2.02. For trial 2 they were: (1) 1.48, 2.96; (2) 1.55, 2.92; (3) 1.59, 2.87; (4) 1.52, 2.91; (5) 1.58, 2.72; (6) 1.59, 2.74; (7) 1.68, 2.72; (8) 1.62, 2.80. For trial 3 they were: (1) 1.26, 3.08; (2) 1.41, 3.06; (3) 1.42, 2.96; (4) 1.50, 2.93; (5) 1.49, 2.92; (6) 1.44, 2.92; (7) 1.42, 2.92; (8) 1.34, 3.14; (9) 1.45, 2.86; (10) 1.47, 2.96.

177. PHOSPHORUS REQUIREMENT OF THE BABY PIG. E. R. Miller*, D. E. Ullrey, C. L. Zutaut, B. V. Baltzer, D. A. Schmidt, J. A. Hoefer and R. W. Luecke, *Michigan State University, East Lansing.*

Thirty-two baby pigs receiving a synthetic milk diet were used in two trials to determine their phosphorus requirement. Levels of 0.2, 0.4 and 0.6% dietary phosphorus were studied in the first trial and 0.4, 0.5, 0.6, 0.7 and 0.8% phosphorus in the second trial. Vitamin-free casein and dibasic calcium phosphate served as the sources of phosphorus in the diet. In both trials the level of dietary calcium was held constant at 0.8%. Zinc and vitamin D_3 were included in the diet at concentrations of 90 ppm and 1800 I.U. per kilogram respectively. Growth rate and feed consumption were depressed only in pigs receiving 0.2% phosphorus. Typical although not extremely severe symptoms of rickets were manifested by pigs on this level. In the first trial increases in dietary phosphorus resulted in significantly higher serum inorganic phosphorus but significantly lower levels of serum calcium and serum alkaline phosphatase. Levels of femur ash, calcium and phosphorus as well as rib and femur specific gravity and femur breaking strength were all positively related to levels of dietary phosphorus intake. Phosphorus and calcium balance were also positively related to dietary phosphorus levels. In the second trial there were no significant differences in rate or efficiency of weight gain between treatments. Serum inorganic phosphorus was maximum in pigs receiving 0.6% dietary phosphorus. Consideration of all the data under the conditions of experiment indicate the phosphorus requirement of the baby pig to be 0.6% for optimum growth and skeletal development.

178. MILK PRODUCTION OF RANGE BEEF COWS AS AFFECTED BY LEVEL OF SUPPLEMENTAL WINTER FEED. A. B. Nelson*, R. D. Furr and M. Velasco, *Oklahoma State University, Stillwater.*

Milk production of 168 grade Hereford range beef cows was estimated at monthly intervals by weighing the calves before and after nursing. In a study starting about 3 months after parturition, fall-calving cows fed a low level of supplemental winter feed produced an average of 3.81±0.44 and 4.21±0.22 lb. of milk in a 24-hour period. Those fed on a higher level produced 5.42±0.30 lb. of milk. The correlations between estimated milk production of the cows and average daily gain of their calves were 0.15, —.31, and 0.53, respectively. In six other lots the range in estimates obtained starting between the first and second month of lactation were from 5.92±0.48 to 6.88±0.82 lb. and the correlations of milk production and gain were from 0.75 to 0.91. The average production at monthly intervals of one of the higher-producing groups was 9.8, 8.4, 7.3, 6.7, 5.3, 6.7, 6.3 and 5.2 lb. for December through July, respectively. The average 24-hour estimates obtained at monthly intervals for one lot of spring-calving cows fed a low level of supplemental winter feed were 5.8, 7.4, 10.5, 7.7, 7.5, 5.8, 3.8, and 1.6 lb. for March through October, respectively. In this particular lot the correlation between milk production and average daily gain from birth to weaning was .76. From birth to May the average milk production was 8.17±5.3 lb. and r=0.90; and from May to weaning milk production was 5.22±0.41 lb. and r=0.46. In this same year the average milk production of the lot of cows fed on the high level of winter feed was 8.12±0.50 lb. and the correlation with daily gain from birth to weaning was 0.55.

179. PALATABILITY AND PERFORMANCE STUDIES ON BABY PIG DIETS. L. P. Nelson* and D. V. Catron, *Walnut Grove Products Company, Inc., Atlantic, Iowa.*

One unexpanded and four expanded baby pig diets were compared in performance and palatability studies. The diets were (1) a commercial pig starter, (2) an expanded diet with 5% added fat, (3) an expanded diet with 10% added fat, (4) No. 3 diet coated with fat, milk and whey, (5) No. 2 diet with 10% sugar. Forty-five 3-week old pigs, averaging 12.5 lb., were allotted from litter outcome groups to 10 pens (two replicates). Average 3-week gain and feed conversion for each diet were, respectively: (1) 12.67, 1.27; (2) 6.11, 2.04; (3) 6.09, 1.96; (4) 7.68, 1.57; (5) 3.61, 2.79. The commercial unexpanded diet was superior in growth and feed conversion to the expanded diets. This may be due to a deleterious effect which may occur to nutrients and additives during the expansion process. Six additional lots were employed for the following diet preference comparisons: 2 vs. 3; 2 vs. 5; 3 vs. 4; 1 vs. 2. Two diets were fed simultaneously in identical feeders whose positions in the pen were rotated daily for a 5-day period. This procedure was repeated so that each lot of pigs was offered all four preference comparisons. The 10% fat diet was preferred over the 5% diet in five of six replicates and constituted 80.4% of the feed consumed. The 10% sugar diet was preferred over the no sugar diet in all replicates and constituted 73.7% of the feed consumed. The uncoated diet was preferred to the coated diet and constituted 99.9% of the feed consumed. There was no preference between the expanded and the commercial diets as each was preferred in three replicates. The expanded diet constituted 51.5% of the feed consumed and the commercial pig starter 48.5%.

180. EFFECT OF HEAT-PROCESSING AND PELLETING CORN FOR STEERS AND LAMBS. H. W. Newland*, W. T. Magee, G. A. Branaman and L. H. Blakeslee, *Michigan State University, East Lansing.*

Two lots of eight beef steers each were individually fed either a mixed ration of ground hay, ground shelled corn and soybean meal, or ground hay, heated (crumbled) corn and soybean meal. Two lamb fattening trials involving a total of 90 lambs were group-fed similar mixed rations as in the steer trial with the comparisons being; regular ground corn, pelleted corn, flaked corn, crumbled corn and a commercially heat-treated corn. In both the steer and lamb trials gains were not related to treatment, but feed efficiency was significantly increased by crumbled corn in the steer trial. In all lamb comparisons mean feed efficiency values for all the various processed corn groups were superior to regular corn. The molar proportion of volatile fatty acids from rumen fluid taken at slaughter time were related to corn processing. Heat-processing sig-

nificantly decreased the acetic:propionic ratio. Carcass comparisons were made.

181. VARYING DIETARY PROTEIN AND ENERGY LEVELS ON THE GAIN AND CARCASS CHARACTERISTICS OF SWINE. W. F. Nickelson*, D. E. Becker, A. H. Jensen, B. C. Breidenstein and H. W. Norton, *University of Illinois, Urbana.*

The effect of varying the dietary calorie-protein ratio was studied with finishing pigs (100–200 lb.) fed at different levels of feed intake. Corn-soybean meal diets were used, and the caloric density was varied by replacing an equal quantity of starch with lard. Increasing the caloric density of the diet by the addition of 15% lard had little or no effect on the daily caloric intake, although fewer calories of metabolizable energy (ME) were required per unit of gain. Varying the calorie-protein ration from 76 to 147 calories of ME per percent of protein failed to influence the rate of gain, but the greater caloric density increased the efficiency. Widening the calorie-protein ratio by the addition of 15% lard had adverse effects upon carcass merit. On the other hand, narrowing the ratio by increasing the protein level from 12 to 18% of the diet in the presence and absence of 15% added lard produced an improvement in carcass merit, particularly as measured by specific gravity and backfat thickness. Diets containing no more than 125 ME calories per percent protein produced the most satisfactory carcasses, rate of gain, and efficiency of gain. Limiting feed intake produced a statistically significant reduction in rate of gain when less than 80% of full-feed was fed. Feeding at 80% of full-feed improved the gain-feed ratio when 12% protein was fed, but efficiency was impaired when 18% protein was fed. Feeding at 70% of full-feed produced a statistically significant improvement in carcass characteristics.

182. EFFECTS OF PHYTIC ACID ON ZINC AVAILABILITY IN RATS AND SWINE. D. Oberleas*, M. E. Muhrer, B. L. O'Dell and and L. D. Kintner, *University of Missouri, Columbia.*

Following our observations that phytic acid decreased zinc availability and produced parakeratosis in swine, the possible use of the rat to study these metabolic interrelationships was investigated. Weanling albino rats were fed diets based on casein and purified soybean protein (Promine) which contained 12% protein and 1.2% Ca. For each lot the type of basal diet, phytic acid content, Zn added and number of animals per treatment are indicated in parenthesis followed by average weekly gain (gm.) for 4 weeks. Lot 1 (casein, 0, 0, 3) 25.0; Lot 2 (casein 0, 100 mg./kg., 3) 25.9; Lot 3 (casein, 1.0%, 0, 6) 10.3; Lot 4 (casein, 1.0%, 100 mg./kg., 6) 23.3; Lot 5 (soybean protein, 0.34%, 0, 3) 13.4; Lot 6 (soybean protein, 0.34%, 100 mg./kg., 3) 26.7. Severe loss of hair and formation of dermal incrustations on the skin occurred on the diets high in phytic acid. Histologically parakeratosis was evidenced in these rats similar to that reported in swine. The deleterious effect of added phytic acid was prevented by zinc supplementation. Blood analysis indicated that phytic acid was not absorbed. Zinc phytate, which is insoluble at the pH of the intestine (pH=6.5—7.0) must be formed causing malabsorption of zinc.

183. STILBESTROL-PROTEIN RELATIONSHIPS IN BEEF CATTLE. M. L. Ogilvie*, E. R. Hauser, W. G. Hoekstra, *University of Wisconsin, Madison.*

An experiment was conducted to study the effects of stilbestrol at a low and a high level of protein intake. Twenty Hereford steers averaging 750 lb. were allotted to four treatment groups of five steers each and individually fed for 100 days. Treatments were as follows: Lots I and II, low protein (8.8%; 300 lb. ground oat straw and 700 lb. ground corn); Lots III and IV, high protein (13.4%; 300 lb. ground oat straw, 550 lb. ground corn, and 150 lb. soybean-oil meal). Lots II and IV also received 30 mg. stilbestrol/head/day. Percent protein in the ration had little effect on the gain and efficiency of the steers. Stilbestrol very markedly increased average daily gain and feed efficiency at both levels of protein. Neither protein intake nor stilbestrol altered significantly the amount of α-amino nitrogen in the blood plasma or in a tissue sample from the *longissimus dorsi* muscle. Steers fed the high protein ration had increased circulating levels of non-protein nitrogen (NPN), while stilbestrol reduced the NPN levels in the plasma. Analysis of composite samples representing the entire left side of the carcass indicated that steers fed stilbestrol contained more protein and moisture and less fat. Carcasses from steers fed the low protein ration contained a significantly greater percent of moisture and less fat than those fed the higher protein ration, however, percent carcass protein was not significantly lowered. Results would indicate that the general effects of stilbestrol were independent of dietary protein intake of beef steers.

184. RUMINANT PURIFIED DIET STUDIES WITH VARIED MINERAL AND CELLULOSE LEVELS. Robrt Oltjen*, Robert Sirny, and Allen D. Tillman, *Oklahoma State University, Stillwater.*

A 3 x 3 factorial arrangement of treatments was used to study the effect of three mineral levels and three cellulose levels on the performance of sheep fed purified diets. Thirty-six 63-lb. sheep, four per treatment, were individually fed during this 45 day experiment. Percent composition of the 5.0% mineral and 40% cellulose ration was as follows: starch 24.35; cerelose, 24.35; cellulose, 40.00; urea, 4.20; corn oil, 1.00; mineral mix, 5.00; ground plastic, 1.00; choline chloride, 0.1; and Vitamins A and D. Cerelose and starch were altered equally to allow for the different levels of minerals and cellulose. Composition of the mineral mix (J. A. S. 18:1522, 1959) was altered by increasing the $ZnSO_4$ to 0.14%. Rations (mineral and cellulose %), daily gains and feed efficiencies respectively were: (3.5—30), .32, 7.4; (5.0—30), .36, 7.8; (6.5—30), .37, 7.7; (3.5—40), .30, 9.6; (5.0—40), .33, 9.1; (6.5—40), .35, 7.6; (3.5—50), .25, 10.8; (5.0—50), .22, 11.3; (6.5—50), .33, 8.9. Sheep consuming the 30% cellulose rations produced greater gains ($P<.05$) and took less feed per lb. of gain ($P<.05$) than sheep consuming the 50% cellulose rations. The effects of cellulose levels, when averaged over all mineral levels, did not differ from linearity ($P<.01$); the 30% cellulose rations promoted faster and more efficient gains. The effects of mineral levels, when averaged over all cellulose levels did not differ from linearity ($P<.05$); the 6.5% rations promoted the best gains.

185. DRIED SKIM MILK IN THE CALF STARTER CONTRIBUTES LITTLE IN A TWO OR THREE WEEK WEANING PROGRAM FOR DAIRY CALVES. F. E. Pardue* and D. R. Jacobson, *University of Kentucky, Lexington.*

Thirty-one 3-day old calves representing the Holstein and Jersey breeds of both sexes were divided into two groups, weaned at 24 days of age, and raised to 87 days of age. Starter I contained 10% dried skim milk. Starter II contained additional corn and soybean oil meal but no dried skim milk. Protein levels were approximately 16.5% for both starters. The inclusion of dried skim milk in the starter had no significant influence on growth rates or appearance of the calves. For Starter I the average daily gain was 1.54 lb., the increase in height at withers was 6.1 in., and the increase in heart girth was 10.2 in. For Starter II the average daily gain was 1.41 lb., the increase in height at withers was 6.3 in., and the increase in heart girth was 10.1 in. For Starters I and II, respectively, D.M. digestibility was 80.2 and 76.4%, crude protein digestibility was 68.9 and 66.0%, and the T.D.N. values were 78.8 and 75.9%. In no case was the difference between the two groups statistically significant. The calves on Starter I consumed an average of 183.5 lb. of milk, 275.0 lb. of starter, and 48.9 lb. of hay as compared to 178.1 lb. of milk, 260.6 lb. of starter, and 46.1 lb. of hay for calves on Starter II. Additional calves weaned after two weeks milk feeding received less than 100 lb. whole milk and gained an average of 1.33 lb. per day to 87 days of age.

186. GAS CHROMATOGRAPHIC MEASUREMENTS OF RUMINAL VFA AS INFLUENCED BY ANTIBIOTICS OR ENERGY AND NITROGEN SOURCES. L. V. Packett and David Groves*, *Purdue University, Lafayette, Indiana.*

A boron trifluoride method of esterification was used to prepare the n-propyl esters of the volatile fatty acids (VFA) extracted from artificial rumen cultures, and resulting esters of formic through n-valeric acid were fully resolved by gas chromatography. The VFA were extracted from acidified artificial rumen fluid with diethyl ether, carefully dried with anhydrous $MgSO_4$, concentrated to 10 ml. and refluxed 5 min. at steam bath temperature with 10 ml. of dry n-propanol containing 125 gm. of BF_3 gas per liter. The VFA esters were extracted in 10 ml. of n-pentane, washed with water to remove propanol, dried with anhydrous $MgSO_4$ and reduced in-vacuo in an ice bath to a volume of 2.0 ml. Aliquots of this material were then subjected to (GC) analysis on a diethyleneglycol-succinate column using a flow rate of 40 ml. of He gas per minute and a column temperature of 76° C. The method was found to be entirely satisfactory for the study of the proportions of VFA in rumen cultures, and was applied to a study of the effects of antibiotics and different energy or nitrogen sources on in-vitro VFA production by ovine rumen microorganisms. Oxytetracycline and chlortetracycline in concentrations of 1.25 to 10 mcg./ml. of artificial rumen fluid, induced a greater acetate to propionate ratio than controls when cellulose was used as the energy source. When casein, urea, and dibasic ammonium citrate were compared isonitrogenously in isocaloric media, casein supported a greater production of propionate relative to acetate, than either urea or dibasic ammonium citrate when either starch or cellulose was the energy source. With each nitrogen source, cellulose supported a greater production of acetate relative to propionate than did starch. Surprisingly high amounts of formic acid were detected in all of the cultures studied.

187. AVAILABILITY OF DIETARY IRON IN DIFFERENT COMPOUNDS FOR YOUNG PIGS. R. A. Pickett*, M. P. Plumlee and W. M. Beeson, *Purdue University, Lafayette, Indiana.*

Three experiments were conducted to determine the availability of dietary iron from eight sources for young pigs. These iron compounds were added to a dried skimmilk semi-purified ration (15 ppm iron) to supply a total of 50 ppm iron in experiments I and II and 80 ppm iron in experiment III. Each treatment group consisted of six 2-week-old pigs. Hemoglobin, hematocrit and RBC determinations were made weekly on each pig during the 42-day experiments. Average initial hemoglobin values were 7, 5 and 10 gm.%, respectively, for experiments I, II and III. Treatments, daily gain and final Hb values for experiment I were: control 0.56, 5.5; Fe_2O_3(USP) 0.64, 6.2; iron carbonate (1) 0.59, 6.3; $FeSO_4 \cdot 2H_2O$(USP) 0.73, 8.9; Jefron 0.72, 6.7; and Ferritose 0.79, 8.0. The sulfate and Ferritose had significantly higher ($P<.01$) and the controls significantly lower ($P<.01$) Hb values than the other treatments. In experiment II, treatments, daily gains and final Hb values were: basal 0.46, 6.5; iron oxide 0.30, 6.6; iron carbonate (1) 0.52, 6.3; iron carbonate (2) 0.47, 6.9; and $FeSO_4 \cdot 2H_2O$(USP) 0.64, 8.1. The ferrous sulfate gave significantly higher gains and hemoglobin values while gains on iron oxide were significantly less than other treatments. Treatments, daily gains and final Hb values in experiment III were control 0.40, 6.5; iron carbonate (1) 0.57, 7.4; iron carbonate (2) 0.52, 6.9; iron oxide 0.55, 7.0; copperas 0.88, 11.9; and $FeSO_4 \cdot 2H_2O$(USP) 0.87, 12.0. Both sources of ferrous sulfate resulted in significantly higher ($P<.01$) gains and hemoglobin values than the other treatments.

188. ENERGY-PROTEIN RELATIONSHIP IN RATIONS FOR GROWING-FINISHING SWINE. G. E. Poley* and R. W. Seerley, *South Dakota State College, Brookings.*

One hundred sixty-eight weanling pigs were used in two experiments to study the effects of dietary energy, type of ration, and quantity of protein on the performance of pigs. Rations in Experiment I were (1) fortified corn and (2) 40% oats replacing corn. Yellow grease was substituted for corn at levels of 0, 4, or 8% of the ration. The crude protein was the same in all rations. In Experiment II, crude protein and energy content of a fortified corn—40% oat ration were studied. Crude protein content of the rations for growing pigs was 13.3 or 15.3%. The ration energy was varied by adding 0, 4, or 8 percent yellow grease. Experiment I average daily gains (feed per lb. of gain) for corn rations with increasing levels of grease were 1.81 (3.37), 1.91 (2.98), 1.88 (2.96) respectively. Daily gains and feed efficiency were 1.76 (3.59), 1.71 (3.37), 1.81 (3.20) for corn-40% oat rations with 0, 4, or 8% grease, respectively. Average carcass backfat, length, percent lean cuts and loin eye were not significantly different. Experiment II average daily gains (feed per lb. of gain)

were 1.65 (3.62), 1.60 (3.54), 1.57 (3.39) for low protein rations with 0, 4, or 8% grease, respectively. Daily gains and feed efficiency were 1.70 (3.52), 1.71 (3.36), 1.78 (3.04) for high protein rations with 0, 4, or 8% grease, respectively. Pigs fed the high protein level gained significantly faster than those fed low protein. Pigs given high protein rations had significantly less backfat, larger loin eyes and higher percentage of lean cuts. Pigs fed rations containing 8% grease had significantly more backfat and less lean cuts than pigs given comparable ration without grease.

189. BLOOD UREA AND RUMEN AMMONIA IN SHEEP AS AFFECTED BY LEVEL AND SOURCE OF CARBOHYDRATE AND PROTEIN. R. L. Preston, L. H. Breuer, and W. H. Pfander, *University of Missouri, Columbia.*

Twenty-seven rations were fed to two fistulated yearling wethers and five ewe lambs to determine in a qualitative way what changes would result in blood urea-N and rumen NH_3-N concentrations. These rations were combinations of: basal, corn starch, casein, zein, urea, corn gluten feed, soybean, cottonseed and linseed meals, steam cracked, pelleted, and ground corns, timothy hay, alfalfa hay, and pelleted alfalfa meal. These rations were fed for 2 weeks; during the second week, blood urea-N and rumen NH_3-N were determined on 2 different days. Samples were taken prior to feeding and periodically for 8 hours thereafter. Urea-N was increased in the 0-time samples in those sheep receiving casein, zein, soybean meal, pelleted corn; and decreased in those sheep receiving corn gluten feed, steam cracked corn and ground corn. Marked variations in blood urea-N after feeding were observed on some rations. Combinations where considerable decrease (>6 mg. %) was observed included corn starch, linseed, soybean and cottonseed meals, pelleted corn, pelleted alfalfa meal; some decrease (1–4 mg. %) occurred with ground corn, steam cracked corn, zein and timothy hay. Marked increase (>6 mg. %) was observed with urea and casein; corn starch decreased the influence of these two nitrogen sources. Initial blood urea may reflect the "quality" of nitrogen absorbed, but is influenced by the intake of starch and nitrogen. Decreased urea after feeding may indicate a shortage of rumen "soluable N" and the passage of greater amounts of blood urea into the rumen, since a marked decrease in rumen NH_3-N was generally also observed.

190. PERFORMANCE OF FATTENING LAMBS FED VARIOUS FORMS OF CORN. R. L. Preston* and W. H. Pfander, *University of Missouri, Columbia.*

Thirty-two wether lambs were assigned to four lots and fed fattening rations where the only variable was the source of corn. Steam flaked, steam cracked, cracked and pelleted corn were tested. The lambs were fed free choice poor quality alfalfa hay (12.6% protein) and a concentrate mix in separate feeders. The concentrate mix was composed of the respective corns plus sufficient soybean meal to give a protein equivalent of 12.5%. Dicalcium phosphate, iodized salt, aureomycin, vitamin A and cobalt were supplemented in all lots. The lambs were fed for 97 days. The results were as follows for the respective forms of corn: ADG (lb./day) —.44, .52, .42, .38; lb. feed/lb. gain —7.5, 6.2, 6.9, 7.3; carcass grade—C—, C—, C—, G+; dressing percent —50.9, 51.0, 51.9, 52.9; carcass gain (lb.) —24.9, 29.8, 24.9, 24.3; percent separable fat —39.8, 41.6, 42.6, 38.5; percent separable lean —41.6, 40.1, 40.1, 42.8; percent fat in long dorsi M. —3.40, 3.41, 3.28, 3.29. Feedlot performance was superior in lambs fed steam cracked corn and poorest in those fed pelleted corn; however, when dressing percent is considered by comparing carcass gain (assuming dressing percent at beginning to be 46), pelleted corn was equal to steam flaked or cracked corn. Lambs fed steam cracked or cracked corn carried more "outside" fat cover; conversely those fed steam flaked or pelleted corn contained more lean. Those fed steam flaked or steam cracked corn carried more "inside" fat. The steam flaked corn appeared to give the "most desirable" distribution of fat.

191. EFFECT OF DIET AND AGE ON PLASMA AMINO ACID LEVELS OF SWINE. F. Puchal*, V. W. Hays, V. C. Speer and J. T. McCall, *Iowa State University, Ames.*

Eight littermate pigs were weaned at 10 days of age onto milk protein (MP) or soybean protein (SP) diets, and blood samples were taken at weekly intervals and analyzed for plasma free amino acids (AA). The concentration of most essential AA was found to increase with age. A reverse trend was noted for most of the non-essential AA. Greater differences between the plasma AA concentration for the two diets were found in the period of 2 to 4 weeks of age, when the SP fed group gains were poor, than in the period of 6 to 8 weeks, during which blood levels reached a value practically the same as those found for the MP fed group; e.g. leucine increased from an average value of 3.1 mg. per 100 ml. in the 2–4 week period to 4.2 mg. for the 6–8 week period for the MP group as compared to 2.2 mg. and 4.1 mg. respectively for the SP fed pigs. In another experiment, eight littermate pigs were weaned to a SP diet with and without methionine supplementation, and the diets changed at weekly intervals. Plasma methionine concentration was markedly increased and decreased when the supplementary methionine was added or withdrawn from the basal diet. From an initial concentration of 0.4 mg. per 100 ml. while on the sow, this value rose to 0.6 mg. when the pigs were weaned to a SP plus methionine diet. If continued on this diet this value increased further to 0.7 mg. while if switched to a non-supplemented basal it decreased to 0.4 mg. per 100 ml.

192. EFFECTS OF SUPPLEMENTAL CELLULASE OR PROTEASE ON NITROGEN AND ENERGY BALANCE AND DIGESTIBILITY OF NUTRIENTS FOR BEEF CATTLE. E. D. Purkhiser*, T. W. Perry and W. M. Beeson, *Purdue University, Lafayette, Indiana.*

Two sets of identical twin calves, one of steers and one of heifers, were used in four digestion trials. A basal ration of corn cobs and protein supplement was hand-fed twice daily at an equal level within twin sets. The control calf of each pair was fed the basal whereas the other received the basal plus either 4 gm. of cellulase or 1 gm. of protease per day. Two experiments were conducted with each enzyme treatment, and the diets were reversed be-

tween each 10-day collection period thus resulting in four controls and four treatments being used to test each enzyme supplement. Nutrient digestibilities and digestible energy were determined in each trial, and nitrogen balance was studied when protease was used. Statistical analysis showed that there were greater variations within sets of identical twin calves than between twin-pairs. Therefore, since each animal was maintained on both the control and treatment diets during separate periods and there were no significant differences in the results from different periods, each animal was used as its own control for the overall statistical analysis. The pooled analysis of variance showed that cellulase significantly ($P<.05$) increased apparent digestibility of crude fiber. The same enzyme had no significant effect on digestible energy or on apparent digestibility of other nutrients. Protease had no significant effect upon the amount of nitrogen retained or apparent digestibility of crude protein. Likewise, the digestibility of other nutrients and energy balance were unaffected by protease.

193. EFFECT OF ENZYMES ON DIGESTIBILITY OF LOW QUALITY ROUGHAGE. A. T. Ralston*, D. C. Church, and J. E. Oldfield, *Oregon State University, Corvallis.*

The nylon bag technique was used with two fistulated steers to determine the effect semi-purified enzymes might have upon the digestibilities of the various components of low quality roughage. After a 10-day equilibrating period to each treatment, finely ground roughage was suspended in the rumen via the rumen-fistula in 10 nylon bags per steer, containing 10 gm. per bag. Duplicate bags were removed from each animal every 24 hours. The samples were washed to remove rumen liquor, dried and subjected to accepted proximate analyses. Five grams of Pectinase, XC 597, HT Protease, Fungal Protease or Fungal Amylase were introduced via the fistula plug daily in gelatin capsules. An empty gelatin capsule was used in the case of the control. Roughage of poor quality was fed during these trials. Small differences were found in digestibility of crude fiber, cellulose and ether extract due to treatment. The digestibility of protein was extremely variable within treatments. Fungal protease was consistent in resulting in higher digestibilities in all components, especially at end of 24 hours. This was not significant at the 0.05 level. The results showed approximately 70% of the digestible ether extract had disappeared at the end of 24 hours whereas it took over 60 hours for 70% of the digestible crude fiber and cellulose to disappear.

194. DIETARY FACTORS AFFECTING VOLATILE FATTY ACID PRODUCTION IN THE RUMEN OF SHEEP. Ned S. Raun* and Wise Burroughs, *Iowa State University, Ames.*

Sodium and potassium bicarbonate (1.0 to 5.0%), calcium carbonate (0.6 to 2.5%) and magnesium carbonate (0.25 to 1.0%) additions were without effect in altering rumen acetate-propionate ratios and total volatile fatty acid levels when feeding lambs rations containing 85% concentrates and 15% roughage. Concurrent sodium bicarbonate and lactic acid supplementation produced ruminal propionate levels no higher than those produced by lactic acid alone. Addition of cobalt sulphate (0.64 ppm Co) narrowed acetate-propionate ratios and lowered butyric acid levels. Dry steam autoclaved corn widened acetate-propionate ratios. Chlortetracycline supplementation (10 mg. lb.) of a high urea (0.7%) lamb fattening ratio tended to overcome the depressing effects of urea on carcass grade and feed efficiency. Chlortetracycline alone tended to widen acetate-propionate ratios and to elevate butyric acid levels. Narrower acetate-propionate ratios, higher butyric acid levels, lower total volatile fatty acid levels and lower pH's were produced in 80% concentrate rations than in those containing 50% concentrates. While overall weight gains were similar between these rations, improved feed conversion, higher dressing percentage, higher percent separable fat and lower percent separable lean resulted in the higher concentrate rations. A high correlation existed between ruminal butyric acid levels and carcass grade.

195. EFFECT OF ENERGY PROTEIN RELATIONSHIP, PHYSICAL FORM OF FEED AND ENVIRONMENTAL TEMPERATURE ON LAMBS. John C. Rea* and C. V. Ross, *University of Missouri, Columbia.*

Five feeding trials were conducted to study the optimum protein levels as measured by feedlot performance of fattening lambs. The effect of varying the energy level of the ration on protein needs was determined, and in two trials pelleted versus meal rations were compared. There was a consistent response in gains when crude protein levels up to 14% of the ration were fed. This was significant in one trial ($P<.05$) and approached significance in another ($P<.08$). A stimulus in gains was noted for lambs receiving up to 17% crude protein rations in one trial. Best average gains were made on rations containing 14% crude protein and approximately 60% concentrate. Lambs fed these rations averaged 16.2% faster gains than those on 14% crude protein and 40% concentrates and 5.5% faster than those on 11% crude protein and 60% concentrate rations. It appeared that differences due to season when lambs were fattened had an influence on the performance of lambs on the high and low concentrate rations. During two winter trials there was little difference in performance of lambs due to concentrate level whereas in two summer trials lambs on high concentrate rations gained significantly faster ($P<.01$) than those on high roughage rations. Lambs fed pelleted rations ate more feed, made faster gains with higher carcass yields and grades than those fed meal. Pelleting high roughage rations appeared to be more beneficial compared with meal than pelleting rations high in concentrate.

196. EFFECT OF ENVIRONMENTAL TEMPERATURE ON GAINS FEED EFFICIENCY AND DIGESTIBILITY OF FEED BY LAMBS. John C. Rea* and C. V. Ross, *University of Missouri, Columbia.*

In four experiments using 568 lambs which were designed to study the effect on fattening lambs of varying proportions of concentrate and roughage, and season of the year, differences in performance of lambs fed high and low concentrate rations were markedly different in summer and winter. In two trials conducted during summer and another in the spring, gains of lambs fed rations containing approximately sixty parts concentrates to forty parts rough-

age were significantly higher than those fed 40% concentrates ($P<.01$). Carcass yields were higher also ($P<.05$), fed per unit of gain was somewhat less, and carcass grades slightly higher. In a trial conducted during the winter months and the first part of a trial initiated in March, however, there were no significant difference in gains of lambs fed high and low concentrate rations. Two metabolism studies were made at environmental temperatures of 40° F. and 80° F. Apparent digestion of crude protein, dry matter, ether extract, and nitrogen free extract was significantly higher for lambs fed 60% concentrates than those on a 40% concentrate rations ($P<.01$). Differences in favor of the high concentrate rations were greater at 80° F. than at 40° F. environmental temperature. In a feeding trial conducted under controlled environmental temperatures gains of lambs fed a high concentrate ration in a warm temperature equalled those fed a low concentrate ration and carcass yields were 6.6% higher. There was no significant differences in performance of lambs fed high or low concentrate rations at a cool temperature.

197. EFFECT OF UREA ON NUTRITIVE VALUE OF HIGH FIBER CONCENTRATES FOR DAIRY CATTLE. B. S. Reddy*, N. F. Colovos, H. A. Keener, and H. A. Davis, *University of New Hampshire, Durham.*

Sixteen individual digestion trials were conducted using four dairy heifers, a pair of identical twin Ayrshires and a pair of twin Holsteins, to study the effect of urea on the nutritive value of high fiber concentrate mixture, which contained corn meal, oat feed, wheat bran, corn gluten feed, Brewers grain, molasses, and soybean oil meal as ingredients. Urea used was in the form of "262" which furnished approximately 0, 9, 18, and 36% of total nitrogen in four concentrate mixtures. The crude protein and fiber contents of concentrate mixtures varied from 15.57 to 17.89% and from 9.62 to 11.03% respectively. A mixed grass hay, in which crude protein ranged from 5.71 to 6.63%, and the concentrates were fed in equal quantities as calculated by Morrison standard. The average digestion coefficients of dry matter of four rations were 64.10, 63.84, 63.64, and 62.83% respectively. The average digestible energy values were 61.71, 61.94 62.04, and 60.88% respectively. The digestibility of crude protein and TDN values were 66.98, 66.91, 63.90, and 65.53% and 64.75, 63.07, 63.17, and 63.41% respectively. The differences between the values were not significant. Nitrogen retention values were found to be 17.13, 19.92, 19.94, and 19.77 gm. The results indicated that dairy heifers were able to utilize satisfactorily the rations in which up to 36% of the total nitrogen was supplied by urea. Urea in high fiber rations was proven to be a useful source of nitrogen.

198. SUPPLEMENTATION OF PELLETED BARLEY-OAT RATIONS FOR STEERS. D. Reimer*, E. C. Frederick, O. E. Kolari and L. E. Hanson, *University of Minnesota, St. Paul.*

Two trials were conducted to determine the value of: (1) a protein supplement in a barley-oats and alfalfa hay ration; (2) dried cane molasses in a barley-oats mixture; and (3) stilbestrol implants for fattening yearling steers. Hereford steers (average good) were fed in four lots of 10 each for 140 days during the winter (Trial 1) and for 112 days during the following summer (Trial 2). Rations consisted of pelleted grain mixtures and alfalfa hay fed free choice with the following four treatments: I. 70% barley, 30% oats pellets plus (1) 1 lb. soybean meal; (2) 1 lb. ground shelled corn; II. 68% barley, 29% oats, 3% cane molasses pellets plus (3) 1 lb. soybean meal; (4) 1 lb. ground shelled corn. One-half of the steers in each lot were implanted with 24 mg. stilbestrol at the outset of each trial. ADG and feed required per cwt. gain, respectively, for Trial 1 were: (1) 2.29, 1059; (2) 2.48, 967; (3) 2.38, 1060; (4) 2.41, 961. Similar data for Trial 2 were, respectively: (1) 2.49, 935; (2) 2.44, 966; (3) 2.38, 945; (4) 2.22, 1016. These results indicate that the addition of a protein supplement did not increase daily gains nor improve feed efficiency, therefore a ration based on alfalfa hay, barley and oats may be considered adequate in protein without the addition of a supplement. The inclusion of cane molasses in the grain pellets did not affect feed consumption, daily gains or feed efficiency. Stilbestrol implants increased daily gains an average of 21.3% (Trial 1) and 24.5% (Trial 2) with no significant effect on live market grade.

199. VOLATILE FATTY ACID PRODUCTION AS INFLUENCED BY PHYSICAL FORM OF THE RATION. Robert W. Rhodes* and Walter Woods, *Iowa State University, Ames.*

The effect of trace mineral supplementation and the pelleting of a ration composed of 67% concentrate and 33% roughage was studied with respect to rumen volatile fatty acid production in lambs. The feeding of a pelleted ration as compared to a meal form ration resulted in a narrowed acetate to propionate ratio when the roughage portion of the ration consisted of alfalfa hay. Iso-butyrate, butyrate, and iso-valerate levels appeared to be lowered by feeding the ration in the pelleted form while the level of valerate was raised. Cobalt supplementation raised propionate levels while lowering butyrate levels. The effects of pelleting a ration in which the roughage portion was ground corn cobs instead of alfalfa hay were similar to the effects noted with the alfalfa ration except that the acetate to propionate ratio was somewhat narrower in the basal meal ration. Complete trace mineral supplementation of the ration containing corn cobs tended to widen the acetate to propionate ratio. A tendency for the level of acetate to increase and that of propionate to decrease with time after feeding was observed. Fistulated lambs did not show as pronounced a response to the different treatments as intact lambs in terms of acetate to propionate ratios. Total volatile fatty acid levels and rumin pH in contrast to volatile fatty acid ratios were not consistently affected by ration treatment.

200. ENERGY AND PROTEIN REQUIREMENT OF BRED GILTS. H. L. Richards, A. J. Clawson* and E. R. Barrick, *North Carolina Agricultural Experiment Station, Raleigh.*

A total of 96 gilts were used in an experiment which was designed as a 2 x 2 x 2 x 2 factorial. The variables were two levels of total nutrient intake —3 lb. vs. 6 lb.; two levels of total protein intake —0.3 lb. vs. 1.2 lb.; two breeds—Duroc vs. Crossbreds and two seasons—Spring and Fall. The gilts

were started on test on the date of breeding. They were fed in replicated lots with concrete floors during gestation. Protein was supplied by dehulled (50%) soybean meal. Corn starch and sugar were used as the energy source. Vitamins and minerals were added to supply the same quantity in the daily allowance of either 3 or 6 lb. of feed. Mean performance criteria for 3 vs. 6 lb. of feed and for 0.3 vs. 1.2 lb. of protein daily, respectively, were as follows: Average weight per gilt at farrowing 358, 445, 395, 408; average weight gain during gestation 75, 163, 111, 127; average number of live pigs farrowed 9.4, 8.9, 8.8, 9.4; average birth weight 2.5, 2.8, 2.6, 2.6; average number of pigs weaned 8.1, 7.9, 7.7, 8.4; average litter weight at weaning 342, 329, 318, 353; average weight per gilt at end of 56-day lactation 384, 421, 398, 408. Treatment differences in daily gain during gestation were significant. Differences in the production criteria measured were not significantly associated with treatments.

201. COPPER AND ZINC INTERRELATIONSHIPS IN SWINE FEEDING. H. D. Ritchie*, E. R. Miller, R. W. Luecke, D. E. Ullrey and J. A. Hoefer, *Michigan State University, East Lansing.*

Sixty weanling pigs were divided into six lots to compare the effects of adding various combinations of copper and zinc to a basal diet which furnished twice as much calcium (1.3%) as currently recommended by the National Research Council. Average daily gains for a 10-week feeding period were as follows: (1) basal, 0.48; (2) basal+125 ppm Cu, 1.09; (3) basal+250 ppm Cu, 1.21; (4) basal+100 ppm Zn, 1.18; (5) basal+100 ppm Zn+125 ppm Cu, 1.26; and (6) basal+100 ppm Zn+250 ppm Cu, 1.24. Gains made by all five experimental lots (2–6) were significantly higher ($P<.01$) than those of the control lot (1). After 7 weeks, there was an 88% incidence of parakeratosis in Lot 1. Development of parakeratosis in Lot 2 was delayed until the 14th week, when there was an incidence of 86%; four of the six cases were considered very mild but the remainder were quite severe. Only one pig in Lot 3 developed any parakeratotic lesions; however, several pigs in this lot exhibited symptoms of copper poisoning—severe anemia, hemolytic jaundice, internal hemorrhage, loss of weight, and, in some cases death. There was no evidence of either parakeratosis or copper toxicity in the three lots receiving supplemental zinc. After 10 weeks, the control lot was divided and half of the pigs were fed the ration containing 250 ppm Cu for 5 weeks; a slow but marked recovery from the parakeratotic symptoms occurred.

202. VITAMIN D, ZINC AND CALCIUM IN SWINE NUTRITION. Harry F. Roberts*, W. G. Hoekstra and R. H. Grummer, *University of Wisconsin, Madison.*

Sixty-four weanling pigs were allotted into eight lots and fed a corn-soybean oil meal type basal diet (1.4% calcium, 29 ppm zinc and 50/I.U. vitamin D/lb.). Three levels of supplemental vitamin D were fed (0, 100, and 100,000 I.U./lb.) with two levels of supplemental zinc (0 and 100 ppm). Two lots received less calcium (0.8%) with no added zinc and 0 or 100,000 I.U. of supplemental vitamin D. As observed previously, feeding high calcium produced severe parakeratosis which was prevented by added zinc and to a lesser degree by lowered dietary calcium. Vitamin D level had no significant effect on the parakeratosis or on body weight gain. The lowest level of vitamin D did not produce readily observable rickets and bone ash was not altered after 21 weeks on experiment. Also, no hypervitaminosis D was observed. Each of the dietary variables has been reported to affect blood plasma alkaline phosphatase. In this experiment, plasma alkaline phosphatase was significantly higher in pigs fed supplemental zinc. During the stage of rapid growth, feeding the low level of vitamin D caused a very marked increase in plasma alkaline phosphatase, but only if added zinc was fed. Supplemental zinc increased bone alkaline phosphatase in animals fed the two lower levels of vitamin D, but not in those fed the high level. The same trend was observed for kidney and liver alkaline phosphatase but not for intestinal phosphatase. Data on tissue levels of zinc will also be reported.

203. EFFECT OF A LYSINE SUPPLEMENT UPON RATION DIGESTIBILITY AND LEVEL OF SOME METABOLITES IN THE RUMEN OF SHEEP. W. K. Roberts*, *University of Manitoba, Winnipeg, Manitoba, Canada.*

A digestibility study with six mature wethers was conducted to determine the effect of lysine supplementation upon ration digestibility and rumen volatile fatty acid (VFA) concentration. The two experimental rations consisted of the following: (A) 50% interlake hay, 37% barley, 10% oats, 1% urea, 1% dicalcium phosphate, 1% salt and vitamin A; (B) ration A plus 45 gm. of feed grade lysine per 100 lb. Energy and dry matter digestibility for A was 66.8% and 66.5%, and for B 64.2% and 64.1%, respectively. Rumen liquor collected from 6 animals per treatment, approximately 1 hour after feeding, showed total VFA concentrations of 74.6 and 84.5 m mol./1 for A and B, respectively. Differences between groups were not statistically significant for either entity mentioned. A subsequent study was conducted with 2 mature wethers fitted with permanent rumen cannulas to determine the effect of time after feeding upon ruminal levels of VFA, ammonia, nonprotein nitrogen (NPN) and total nitrogen (TN). Rumen fluid was collected at 0, ½, 1, 1½, 2, 2½, 3, 4, 5 and 6 hours after feeding. Total concentration of VFA was greater in all cases in rumen liquor from animals receiving ration B, and reached a maximum concentration 2 hours after feeding. Rumen liquor ammonia and NPN concentrations were greatest in animals receiving ration B at all sampling periods with exception of 1½ hours after feeding. Maximum concentrations of ammonia and NPN were observed 1 hour after feeding in both treatments.

204. PALATABILITY OF CREEP RATIONS FOR SUCKLING LAMBS. C. V. Ross* and W. H. Sellers, *University of Missouri, Columbia.*

Further studies on the effect of palatability of creep rations on performance of suckling lambs were made with 118 lambs. Shelled corn was again compared with complete pelleted rations. In the initial comparison the formula contained 60% ground yellow corn, 30% soybean oilmeal and 10% dehydrated

alfalfa meal. Since the lambs failed to eat the pelleted ration readily, another ration was introduced at the end of five weeks. This ration composed of 60% ground yellow corn, 30% soybean oilmeal, and wheat bran 10%, was offered to the lambs along with the other complete ration. Lambs ate slightly more than twice as much of the ration containing bran as they did of the first ration which contained dehydrated alfalfa meal. Overall, lambs on the pelleted complete creep rations ate 178% more feed and gained 12% faster (significant $P<.05$) than similar lambs fed corn in creeps. Difference in gains were greater in twins ($P<.01$) than for singles. Lambs on the pelleted complete ration had more bloom and graded higher at slaughter. In further tests of palatability a ration containing 60% ground corn, 30% soybean oilmeal and 10% wheat bran was consumed twice as readily as shelled corn. Replacing the bran with dehydrated alfalfa meal apparently reduced palatability to 144% that of shelled corn. Increasing the dehydrated alfalfa meal content in creep rations appeared to decrease palatability. In every case pelleting creep rations almost doubled acceptability of mixtures.

205. CONSISTENT BEEF CATTLE RESPONSES TO SPECIFIC ENZYME FEEDING PROGRAMS. J. J. Rovics and C. M. Ely*, *Biological Research Laboratories, Nopco Chemical Company, Harrison, New Jersey.*

Collective results from nine University and/or practical feedlot trials showed an 82% consistency in the number of positive responses when beef cattle were fed a crude fungal-bacterial enzyme source (NOPGRO) at supplemental levels ranging from 0.005 to 0.02 lb./head/day. This percentage rating is based on direct "with and without" comparisons of 17 enzyme treated lots (532 cattle) with 13 negative control groups (576 cattle). The basal regimes used in this series of experiments varied grain-roughage-protein supplement interrelationships, however, all but a minor percentage contained DES at 5–10 mg./head/day. Optimum benefits from enzyme feeding occurred from the continuous use of 0.005 to 0.01 lb. of NOPGRO over the full fattening cycle. Significantly greater improvements in average daily gain and feed conversion occurred in low protein (10–10½%), high roughage rations than in diets containing 11–12% protein and less fiber. An average improvement of 0.235 lb./head/day was observed in two University studies on NOPGRO in low protein rations. At a supplemental cost of less than one-half cent per steer daily, responses greater than .02 lb./head/day showed a profitable return from the enzyme additions.

206. VITAMIN K DEFICIENCY IN THE NEWBORN PIG. Harold E. Schendel* and B. Connor Johnson, *University of Illinois, Urbana.*

Vitamin K has been shown to be an essential nutrient for newborn pigs housed in raised wire-bottom cages and fed a "synthetic" liquid diet. Fourteen out of 15 animals developed symptoms which include a highly significant increase in prothrombin time, hypersensitivity, anorexia and weakness. Whereas the animals die by the fourth or fifth week if they do not receive some source of this vitamin, they respond clinically and biochemically to the oral or intramuscular injection of menadione (diphosphate ester) in 2 to 4 hours. Using prothrombin time as the criterion, the dietary requirement of newborn pigs for menadione is approximately 5 mcg./kg. body weight/day and the minimum curative injected dose is something less than 20 mcg./kg. body weight. *Other observations:* 1) The data also suggest that the newborn animal develops symptoms before it begins to root or practice coprophagy and consequently elaborate measures to prevent coprophagy do not appear to be essential. Conversely while older animals (3 months) placed in coprophagy-preventing cages do develop prolonged prothrombin times, they are not grossly abnormal. Perhaps a small amount of vitamin K synthesized in the gut is absorbed. 2) Short-term observations of one and two weeks duration suggested that even therapeutic levels of a bacteriostatic agent, e.g., sulfathalidine, in the diet had little effect on vitamin K deficiency. 3) The mean hematocrit for 7 vitamin K-deficient pigs was 29.6% compared with 42.7% ($P=0.05$) for the 6 control animals. During treatment with orally administered menadione for one week, the mean hematocrit for the deficient group increased to 37.5% ($P<0.05$).

207. INFLUENCE OF FAT ON THE VITAMIN B_6 REQUIREMENT OF SWINE. R. F. Sewell* and Mugawilage M. Nugara, *University of Georgia, Athens.*

Ninety 3-week old pigs were used in three experiments to study the effect of dietary fat level on the vitamin B_6 requirement of the pig. Purified diets were employed in each experiment using corn oil as a source of fat. In Experiment 1, six diets containing two levels of fat with three variations in caloric density were fed with and without supplemental vitamin B_6. Highly significant differences in gains resulted from supplemental vitamin B_6 at each caloric density studied. Pigs receiving the low-fat diet without supplemental B_6 grew more slowly with a more rapid appearance of the deficiency syndrome than did pigs receiving the high-fat diets without B_6 supplementation. In Experiment 2, five dosage levels of vitamin B_6 were fed to determine the vitamin B_6 requirement at a dietary fat level of 2%. Experiment 3 employed similar dosage levels to study the B_6 requirement at a dietary fat level of 12%. A logarithmic curve was constructed in which growth response was plotted against vitamin B_6 dosage level for Experiments 2 and 3. Results indicate a vitamin B_6 requirement of 0.53 mg. per lb. of feed at the 2% fat level with a requirement of 0.31 mg. per lb. of feed at the 12% fat level. Under the conditions imposed in these experiments, increasing the level of corn oil in the diet appeared to spare the vitamin B_6 requirement of the pig.

208. EFFECT OF PROTEIN LEVEL AND ENVIRONMENTAL TEMPERATURE ON PERFORMANCE AND CARCASS QUALITY OF SWINE. E. W. Seymour*, V. C. Speer, D. W. Mangold, T. E. Hazen and V. W. Hays, *Iowa State University, Ames.*

Ninety-six pigs were used in an experiment of split plot design to study the effects of temperature and protein on growth rate, feed efficiency, and carcass quality of swine housed and fed in confinement from 3 weeks of age to market weight (15 to 200 lb.). Four temperature treatments con-

sisted of: (1) 60° from 3 wk. to market, (2) 40–50° from 3 wk. to market, (3) 60° from 3 wk. to 125 lb. and 40–45° from 125 lb. to market, and (4) the reverse of treatment 3. Two protein levels (20% and 16% initially and each reduced 3% after 4 wks. and again when the pigs averaged 115 lb.) were fed to investigate the possibility of temperature x protein interaction. Pigs on the high level of protein yielded 51.0% of the carcass as lean cuts as compared to an average yield of 48.5% for those on the low level of protein. The high level of protein also significantly increased average daily gain (1.55 vs. 1.45 lb.) and decreased carcass backfat (1.66 vs. 1.81 in.), ($P<.05$). The pigs started at 60° temperatures tended to produce slightly less backfat, a higher percentage of lean cuts and required less feed per lb. of gain than did those started at the lower temperatures. The over-all feed conversion was not significantly influenced by protein or temperature and there were no statistically significant temperature x protein interactions.

209. AVITAMINOSIS IN CATTLE FED SILAGE RATIONS SUPPLEMENTED WITH VITAMIN A. G. S. Smith*, A. L. Neumann, W. G. Huber, H. A. Jordan and O. B. Ross, *University of Illinois, Urbana.*

Calves wintered on various feeds were examined in April for vitamin A status. Feeds, number per group, and contents of vit. A (mean ± std. dev.) in plasma (mcg.%) and liver (mcg./gm. fresh liver) were: corn silage + soybean meal (SBM) (6): 46±8, 21±11; dwarf corn silage + SBM (5): 48±16, 45±19; grain sorghum + SBM (3): 58±3, (18, 24, 91); grain sorghum + SBM + hay (3): (41, 55, 53), (151, 65, 80); corn silage + SBM + hay (6): 42±8, 23±16; and dwarf corn silage + SBM + hay (7): 50±9, 27±11. Twelve calves fed drilled corn silage + SBM did poorly and were changed in February to a ration of grain sorghum + SBM. Six of these were fed daily approx. 20,000 I.U. preformed vit. A per head. In April plasma and liver contents of vit. A in unsupplemented versus supplemented groups were: 45±7 versus 42±18 mcg.% and 37±24 versus 37±13 mcg./gm. fresh liver. In another study, heavy steer calves were full-fed for 168 to 224 days corn silages containing carotene in excess of 5 mg./lb. fresh silage. They were fed daily 5,000 to 7,000 I.U. preformed vit. A in SBM. Poor gains and apparent symptoms of vit. A deficiency were observed in June after silage intake was reduced to 15 lbs. and corn was full-fed. Contents of vit. A in plasma and livers were 26±5 mcg.% and 3.9±2.0 mcg./gm. Increasing the supplemental vit. A level to 100,000 I.U. daily for 3 to 5 weeks elevated plasma levels to 50–60 mcg.% and liver levels to 40–50 mcg./gm. Ophthalmoscopic examinations were made and conjunctival smears studied to determine their usefulness in providing early indication of vit. A deficiency in fattening cattle.

210. ERYTHROMYCIN THIOCYANATE OR ITS SPENT BROTH FOR FATTENING STEERS. I. D. Smith*, H. S. Perdue, J. A. Kolar, B. A. Christianson, and D. V. Frost, *Abbott Laboratories, North Chicago, Illinois.*

Four experiments, each involving 100 steers, were conducted to evaluate growth stimulation of various levels of erythromycin thiocyanate (ET) or spray dried erythromycin spent broth (SDESB). This performance in fattening steers was compared with that of steers fed chlortetracycline or Agrozyme. The SDESB served as a crude source of protease and amylase. For Exp. I (168 days) feed additives (per head per day), average daily gains (lb.), feed/cwt. gain (lb.) and dressing % were: (1) Basal—2.30, 955, 61.51; (2) Agrozyme 3.5 gm.—2.25, 983, 62.17; (3) SDESB, 3.5 gm.—2.35, 943, 61.90; (4) SDESB 14.0 gm.—2.44, 912, 61.76. In Exp. II (112 days) half of the steers in each lot were implanted with 24 mg. of diethylstilbestrol. Feed additives, average daily gains for the implanted steers, average daily gains for the non-implanted steers and average feed/cwt. gain for implanted and non-implanted steers combined were: (1) Basal—2.94, 2.64, 873; (2) SDESB 3.5 gm.—3.14, 2.61, 849; (3) SDESB 7.0 gm.—3.11, 2.65, 848; (4) SDESB 14.0 gm.—3.25, 2.64, 824. Exp. III lasted 112 days. The additions were: (1) Basal; (2) SDESB 14.0 gm.; (3) SDESB 14.0 gm.—heated to destroy enzymatic activity; (4) ET 80 mg. Only the last of these (ET 80 mg.) improved weight gains (4.1%) and feed efficiency (4.2%). For Exp. IV (154 days) feed additives, average daily gains, feed/cwt. gain and dressing % were: (1) Basal—2.19, 1091, 59.24; (2) ET 40 mg.—2.39, 1007, 59.34; (3) ET 80 mg.—2.30, 1045, 58.52; (4) Chlortetracycline 80 mg.—2.38, 1008, 58.90.

211. EFFECT OF VITAMIN A SUPPLEMENTATION ON A CORN-SOY RATION FOR SWINE. W. H. Smith*, R. A. Pickett, J. H. Conrad and W. M. Beeson, *Purdue University, Lafayette, Indiana.*

Two experiments were conducted using 72 pigs with an average initial weight of 40 lb. Experiment I was conducted during the winter. A corn-soy ration containing 0.54 mg./lb. of carotene was fed. The second expt. was conducted during the summer and a similar ration, the carotene content being 0.45 mg./lb., was used. In both experiments, the following dietary levels of vitamin A were fed: Lot I, 0; Lot II, 400; Lot III, 800; and Lot IV, 1600 I.U. The average daily gains for the lots in Expt. I were 1.58, 1.65, 1.62 and 1.60 lb., respectively. In Expt. II the average daily gains for the respective treatments covering a 70-day period were 1.47, 1.54, 1.57 and 1.53 lb. The differences in growth were not significant in either expt. Feed required per lb. of gain in Expt. I was 3.60, 3.62, 3.60 and 3.65 lb. for Lots 1 through 4, respectively. In Expt. II the feed required per lb. of gain for Lots 1, 2, 3 and 4 was 2.99, 3.06, 2.97 and 3.15 lb., respectively. In both experiments the plasma vit. A was significantly increased ($P<.01$) with each level of vit. A added when compared to the control group. There was a linear increase of vit. A in the liver of 18.1, 79.9, 141.0 and 264.4 I.U. per gram for Lots 1 through 4, respectively, in Expt. I. Plasma vit. A levels in Expt. II were 24.9, 36.2, 38.5 and 40.6 mcg./100 ml. plasma for Lots 1 through 4, respectively. These results indicate that the level of carotene in the basal corn-soy ration is adequate to maintain an optimum growth rate and apparently normal plasma vit. A level in growing swine. Additional vit. A beyond 400 I.U. would serve only to increase the liver storage of the vitamin.

212. EFFECTS OF INORGANIC SULFUR ON KNO_3 UTILIZATION BY LAMBS. J. H. Sokolowski*, U. S. Garrigus, and E. E. Hatfield, *University of Illinois, Urbana.*

Twenty white-faced Southwestern lambs averaging 80 lb. were individually self-fed the following rations: *A*-Basal—no KNO_3, 0.501% sulfur (1.39% N); *B*—3.2% KNO_3, 0.096% sulfur (1.59% N); *C*—3.2% KNO_3, 0.516% sulfur (1.66% N); *D*—3.2% KNO_3, 0.920% sulfur (1.59% N). Average daily gains were: 0.489, 0.383, 0.369, 0.446 lb. per day, respectively. Average daily gain was significantly depressed ($P<.05$) in B and C as compared to A but no significant difference occurred between A and D. Nitrogen and sulfur balances were: 3.95, 3.35, 5.60, 3.65, and +0.67, −0.80, +1.21, +2.86 gm. per lamb per day, respectively. The difference obtained in sulfur retention were highly significant ($P<.01$). A significant depression ($P<.05$) was found in carcass grade due to the nitrate treatment, with no apparent effect of sulfur being noted. No statistically significant differences were found in nitrogen balance, wool growth, feed consumption, dressing percent, thyroid, adrenal or pituitary weight, wool nitrogen, liver Vitamin A, or rumen pH. Liver Vitamin A values were low on all treatments (19, 28, 26, 30 mcg. Vitamin A per gm. fresh tissue). Wool growth (gm. per cm^2) was increased 9% by the addition of nitrate nitrogen with no apparent effects noted due to the addition of inorganic sulfur. This trial supports previous reports by this station that nitrate nitrogen is apparently utilized in a manner similar to other forms of NPN when fed to lambs. The addition of inorganic sulfur to give 0.5% to 0.9% sulfur in the ration appears to aid in the prevention of toxic effects of KNO_3 by increasing the utilization of the nitrate N by the growing-fattening lamb.

213. INFLUENCE OF AGE OF PIG AND LEVEL OF FEED INTAKE ON THE METABOLIZABLE ENERGY VALUE OF THE DIET. J. T. Tollett*, A. H. Jensen, and D. E. Becker, *University of Illinois, Urbana.*

The effects of age and level of feed intake upon the energy and nitrogen utilization were studied in the pig. A 16% fortified corn-soybean meal diet was fed. Pigs of three ages (35, 90 and 160 days) were fed four levels of feed (maintenance, two-times maintenance, three-times maintenance, and full feed). Following a 10-day preliminary period the pigs were on a 5-day balance trial. At all three ages, the full-fed pigs yielded similar values for the digestible and the metabolizable (corrected for nitrogen balance) energy values of the diet. However, at 35 and 90 days of age the digestible energy and metabolizable energy values increased with increased feed intake, but at 160 days of age the highest values were obtained at the maintenance level of feeding. The nitrogen digested, expressed as a percent of the total nitrogen consumed, increased significantly as the pigs grew older. Nitrogen digestibility was maximal at two- or three-times maintenance for pigs at 35 and 90 days of age and at maintenance for the pigs at 160 days of age. The maximum level of nitrogen retention, expressed as a percent of the total nitrogen consumed, was at full feed for the pigs at 35 days of age and at three-times maintenance for pigs at 90 and 160 days of age.

214. ALFALFA SILAGE VS HAY FOR RABBIT GROWTH AND THUS RATE OF I^{131} UPTAKE. J. W. Thomas*, R. W. Miller and J. H. Vandersall, *Dairy Cattle Branch, A.R.S., U.S.D.A., Beltsville, and University of Maryland, College Park.*

Four separate trials were performed using 84 young growing rabbits solely fed on various hays and companion silages to determine if the growth response of the rabbits would correspond to the performance of milking cows fed these same forages. The same comparative growth response was produced by one silage and its companion hay when the silage was fed in the fresh or in a dried and pelleted state. This silage was inferior to its companion hay in all four trials. The respective gains were 4 vs 25 gm./day ($P=<0.01$) in a 9-week trial. These two forages produced a significant (5%) difference in milk production when fed to cows in favor of the hay. Another companion hay and silage when fed to rabbits in a 1 or 9 week trial produced no statistically significant differences in rate of gain. In the longer trial the gains averaged 25 gm. hay for silage and 32 gm. for hay. This companion hay and silage when fed to dairy cows produced no difference in milk production. The results of these trials indicate that rate of growth and forage intake of rabbits varied for different alfalfa crops as well as for different silage-hay comparisons. The possibility of using rabbit performance to evaluate small quantities of forages appears worthy of further investigation. No consistent differences were found for rabbits fed hay compared to those fed silage in size of thyroid glands, their uptake rate of I^{131} or radioactivity in the butanal soluble portion of blood serum. This was when the forages were fed for 1, 5 or 9 weeks prior to I^{131} injection.

215. STEAM OR DRY ROLLED BARLEY IN HIGH CONCENTRATE RATIONS FOR FATTENING BEEF STEERS. O. O. Thomas* and L. L. Myers, *Montana Agricultural Experiment Station, Boseman.*

Hereford steers were used in three trials designed to determine the effect of level of hay intake and/or preparation of barley upon weight gains and feed efficiency. In trial 1, steers averaging 840 lb. were fed in 4 lots of 10 each. Lots 1, 2, and 3 were fed steam rolled barley with 6, 2, and 0 lb. of hay per head per day, respectively. Lot 4 steers were fed dry rolled barley with 2 lb. of hay. All steers were fed 2 lb. of a 20% protein supplement. During the 140-day trial, the daily gains and feed required per cwt. gain were as follows: Lot 1, 2.15, 1149; Lot 2, 2.50, 924; Lot 3, 2.37, 875; Lot 4, 2.50, 936. In trial 2, 48 Hereford steers averaging 450 lb. were divided into four lots and fed 84 days; the average daily ration was 3.5 lb. barley, 8 lb. mixed hay, and 2 lb. of a 20% protein supplement. Lot number, preparation of barley, and average daily gains are as follows: Lot 1, steam rolled, 1.75 lb.; Lot 2, steam rolled with molasses, 1.73 lb.; Lot 3, steam rolled with molasses and celluade, 1.69 lb.; Lot 4, dry rolled, 1.70 lb. These steers averaging 585 lb., were continued on the same treatments during the fattening phase of the experiment reported as trial 3. All steers were fed 1 lb. per head per day of a 20% protein supplement and only 2 lb. of hay were fed per head per day after the first 42 days. After 140 days on trial, the Lot number, preparation of barley,

and average daily gains are reported as follows: Lot 1, steam rolled, 2.60 lb.; Lot 2, steam rolled with molasses, 2.50 lb.; Lot 3, steam rolled with molasses and celluade, 2.50 lb.; Lot 4, dry rolled, 2.30 lb.

216. WINTER RATIONS FOR CARCASS QUALITY: INTERACTIONS WITH DES IN FATTENING STEERS. G. B. Thompson*, R. L. Preston, and H. B. Hedrick, *University of Missouri, Columbia.*

This experiment was a study of the effects of two protein and two energy levels in winter rations on the carcasses of beef calves. The effects of hormone implants (24 mg. DES) on wintering performance and reimplanting (36 mg. DES) on fattening performance and carcass quality were also studied. Forty-eight 475 lb. steer calves were fed in eight lots with four nutritional treatments replicated and hormone treatments imposed across all lots. The energy levels represent 100% NRC requirement for fattening (HE=9.5 lb. TDN) and 100% NRC wintering requirement for wintering for one pound daily gain (LE=7.0 lb. TDN). The protein levels represent 100% NRC fattening requirement (HP= 1.6 lb. CP) and 75% NRC requirement for wintering (LP=1.0 lb. CP). After the wintering period all cattle were fattened on the same fattening ration and slaughtered as the combined wintering and fattening gain was 500 lb. The higher protein and energy levels of the winter ration resulted in greater gain response to hormone both in the winter period and during the subsequent fattening period. Carcass grade, marbling and conformation scores increased with the higher protein and energy levels fed during the winter phase. Energy level produced the greatest effect; however, protein level had the greatest effect on increasing outside fat cover. A slightly negative gain response to DES implants during the winter phase resulted when low protein rations were fed. Gain response to DES implants during the fattening phase was 12% and 28% for steers previously fed low and high protein winter rations respectfully.

217. EFFECT OF GLUTAMIC ACID SALTS UPON PIG STARTER ACCEPTANCE. G. W. Thrasher*, J. N. Henson and P. D. Bogdonoff, *Commercial Solvents Corporation, Terre Haute, Indiana.*

Eleven preference trials involving 73, 3-week-old pigs fed pelleted pig starters containing 0, 5 or 15% sucrose plus various additions of monosodium glutamate (MSG), ammonium glutamate (AG) or glutamic acid fermentation product (GAFP) were conducted to determine the taste appeal and sucrose substitution values of the glutamic acid salts. Pigs in each preference trial were fed a choice of two starters for five weeks. Feeders were interchanged every three days and replaced with clean feeders every six days. Comparisons and relative consumption percentages were as follows: (1) 0% sucrose vs. 0% sucrose + 1.0% MSG, 8%:92%; (2) 15% sucrose vs. 15% sucrose + 1.0% MSG, 40%:60%; (3) 15% sucrose vs. 15% sucrose + 1.0% MSG, 20%:80%; (4) 15% sucrose vs. 15% sucrose + 0.5% MSG, 17%:83%; (5) 15% sucrose vs. 15% sucrose + 1.0% GAFP, 53%:47%; (6) 15% sucrose vs. 15% sucrose + 1.0 GAFP, 40%:60%; (7) 15% sucrose vs. 5% sucrose + 1.0% MSG, 45%:55%; (8) 15% sucrose vs. 5% sucrose + 1.0% MSG, 92%:8%; (9) 15% sucrose vs. 5% sucrose + 0.5% MSG, 80%: 20%; (10) 15% sucrose vs. 5% sucrose + 1.0% GAFP, 65%:35%; (11) 15% sucrose vs. 5% sucrose + 1.0% AG, 97.5%:2.5%. Results indicate that pigs prefer starters containing MSG regardless of the sucrose level, but the sucrose substitution value of MSG must be further evaluated.

218. ANEMIA STUDIES WITH FERRIC AMMONIUM CITRATE AND REPOSITORY B_{12}. D. E. Ullrey*, E. R. Miller, Esther Ruckle, R. W. Luecke and J. A. Hoefer, *Michigan State University, East Lansing.*

Eighty-nine baby pigs were used to establish whether a repository vitamin B_{12} administered intramuscularly plus an intramuscular injection of 150 mg. of iron as iron-dextran was more efficacious in preventing anemia and promoting growth than the iron-dextran alone. A single injection of either 15 mcg. of B_{12} per kg. of bodyweight or 120 mcg. of B_{12} per pig plus iron-dextran administered from 3 to 7 days of age did not significantly affect hemoglobin, hematocrit, mortality or growth rate when compared to the effects of iron-dextran alone. Eighty-eight different baby pigs were injected subcutaneously with either 100 or 150 mg. of iron as ferric ammonium citrate or intramuscularly with 150 mg. of iron as iron-dextran. Pigs receiving iron-dextran were significantly heavier at 5 weeks post-injection and had higher hemoglobin and hematocrit values and lower mortality than did those receiving 100 mg. of iron as ferric ammonium citrate. Pigs receiving 150 mg. of iron as ferric ammonium citrate were signifiacntly lighter at one week post-injection and had lower hematocrit values at 3 weeks and much higher mortality (47%) than did pigs receiving iron-dextran.

219. EFFECT OF DIETARY LYSINE LEVEL ON MUSCLE SIZE AND COMPOSITION IN SWINE. P. E. Vipperman*, H. R. Thomas, R. F. Kelly, P. P. Graham, and C. C. Brooks, *Virginia Polytechnic Institute, Blacksburg.*

Thirty-six weanling pigs were divided into six lots. Lots 1 through 5 were fed a corn-peanut oil meal ration supplemented with 0.0, 0.3, 0.6, 0.9, and 1.2% L. Lysine HCl, respectively. Lot 6 received a corn-soy ration. All rations contained a standard vitamin, antibiotic, and mineral supplement. The protein level was lowered from 16% to 14% to 12% at 75 and 150 lb., respectively. Lysine supplements were lowered at a corresponding rate. Results indicated an increase of total muscle mass with lysine supplementation. The carcass sp. gr. increased, reaching a maximum at the 0.9% lysine level. The yield of skinned ham, Boston butt, picnic, and trimmed loin increased, and the total lean yield increased ($P<.01$), while trimmed fat decreased ($P<.05$). The weight of the *l. dorsi* muscle increased from 2.2 lb. average in the basal to 3.3 lb. average in the 0.6% lysine lot ($P<.01$). The percent protein of the *l. dorsi* (wet) increased from 19.6% in the basal to 24.4% in the 0.9% supplement lot ($P<.01$). The intramuscular fat decreased as the protein increased while the % water remained constant. Microbiological assay showed no significant change in lysine level of the *l. dorsi* muscle when expressed as a percent of the protein. The ash con-

tent varied directly with the protein level in the muscle. There appeared to be no difference in eating quality of the muscle portion of the pork loin roast due to lysine treatment as indicated by an experienced taste panel or either of two tenderness measuring machines.

220. EFFECT OF ENERGY AND PROTEIN INTAKE AND SEX ON GROWTH AND FEED EFFICIENCY OF PIGS. G. R. Wagner*, A. J. Clark, V. W. Hays, V. C. Speer and J. T. McCall, *Iowa State University, Ames.*

Three experiments involving 492 pigs were conducted to study the effect of dietary protein and dietary energy on rate of gain (ADG in lb.) and feed/gain (F/G) of barrows, gilts and boars. In the first trial increasing the productive energy level from 950 to 1170 Cal./lb. increased ADG (1.53 vs. 1.63) and sig. ($P<.05$) decreased F/G (3.32 vs. 2.64). Also, increasing the protein level from 13 to 19 to 25% significantly decreased ADG (1.68, 1.59 and 1.48), and F/G (3.07, 2.95 and 2.93). Barrows gained faster than gilts and required more feed per unit gain, however, the sex effect was not significant. In the second trial, increasing the metabolizable energy level from 1310 to 1640 Cal./lb. significantly increased ADG (1.24 vs. 1.38) and decreased F/G (4.09 vs. 3.08). Increasing the protein level from 13 to 19% increased rate of gain (1.34 vs. 1.38), however, rate of gain significantly decreased from 13 to 25% (1.34 vs. 1.22). Increasing the protein level from 13 to 19 to 25% increased F/G (3.55, 3.58 and 3.63). Boars gained slightly slower than gilts and required significantly less feed per unit gain. In the third trial, 12 ration treatments, 3 levels of protein (12, 15 and 18%) and 2 levels of metabolizable energy (1290 and 1630 Cal./lb.) with and without amino acid supplementation (0.1% Met. and 0.1% Lys.) were compared. Increasing the energy level from 1290 to 1630 Cal./lb. significantly increased ADG (1.58 vs. 1.73) and decreased F/G (3.88 vs. 2.93). Also decreasing the protein level from 12 to 15 to 18% decreased F/G gain (3.46, 3.41 and 3.34). Increasing the protein level from 12 to 18% decreased ADG (1.67 vs. 1.62). There were no significant effects from amino acid addition and no significant protein x energy interactions in any of the experiments.

221. INFLUENCE OF NITRATE ON PERFORMANCE AND VITAMIN A STATUS OF FATTENING CATTLE. B. A. Weichenthal*, R. J. Emerick, L. B. Embry and F. W. Whetzal, *South Dakota State College, Brookings.*

Sixteen lots with eight yearling beef steers each were fed an 80% ground shelled corn and 20% ground alfalfa hay ration using four treatments, replicated with and without 1% $NaNO_3$ in the total ration. The treatments were: (1) control (approx. 10.3% protein); (2) control plus soybean oil meal (approx. 11.4% protein); (3) control plus vitamin A; and (4) control plus soybean oil meal plus vitamin A. A supplement fed at a ratio of 1:10 with the hay-grain mixture was used to supply the vitamin A, providing an average of 11,050 I.U./head daily. No attempt was made to deplete the cattle of vitamin A reserves initially. However, all of the cattle were fed low quality grass hay for several weeks followed by the control ration for approximately 5 weeks before starting the treatments. The average daily gain for the respective treatments without nitrate were: Rep I (160 days), 2.90, 2.73, 2.75 and 2.72; and Rep II (153 days), 2.92, 3.05, 3.08 and 3.08. The average daily gains for the respective treatments with nitrate were: Rep I, 2.06, 2.48, 2.40, and 2.46; and Rep II, 2.54, 2.55, 2.58, and 2.28. There appeared to be no consistent response to the addition of soybean oil meal or vitamin A to the rations. The feeding of $NaNO_3$ reduced feed consumption and weight gains but resulted in the formation of relatively small quantities of methemoglobin. Initial plasma vitamin A levels for all cattle averaged 30.4 mcg./100 ml. At the termination of the experiment this had declined to an average of 23.0 mcg. for the vitamin A supplemented cattle and 17.2 mcg. for the unsupplemented cattle. The feeding of $NaNO_3$ appeared to have no effect on plasma vitamin A levels.

222. TECHNIQUE FOR REARING GERMFREE PIGS. C. K. Whitehair*, G. L. Waxler, P. C. Trexler and R. F. Hakes, *Michigan State University, East Lansing and Notre Dame University, Notre Dame.*

A series of experiments were conducted in obtaining and rearing baby pigs germfree or in the presence of known species of bacteria to the age of approximately 3 weeks. Vinyl-film isolators were used to collect the pigs from the anesthetized pregnant sow either by hysterectomy or cesarean operation and for rearing the pigs. The isolators were sterilized with peracetic acid and air entering the units was sterilized by passing it through 4 layers of glasswool mat. The diet was composed of cow's milk with vitamin and mineral supplements and was sterilized with steam under pressure. Pigs nursing the sow or reared artificially in open metabolism cages were significantly heavier at the end of the 3-week period than were the pigs reared under germfree conditions. On histopathological examination the germfree pigs had less connective tissue in the submucosa of the intestine and less development of the hepatic interlobular septa. The amount of lymphatic tissue in the small intestine and mandibular area was significantly less in the germfree pigs than in pigs nursing the sow. No definite pattern was found in comparing other organ and tissue weights.

223. DIFFERENT ROUGHAGES AT LOW LEVELS IN STEER RATIONS. J. L. Williamson*, H. B. Geurin, J. C. Thompson, W. S. Teter, D. K. Hotchkiss, H. L. Wilcke, and R. M. Bethke, *Ralston Purina Company, St. Louis, Missouri.*

Ground corn cobs (GCC), Cottonseed hulls (CSH), Soybean hulls (SBH), Rice hulls (RH), Ground rice hulls (GRH), Ground peanut hulls (GPH), Bermuda screenings (BS), Oat mill feed (OMF), ¼ in. chopped alfalfa hay (ALF) and dried beet pulp (DBP) were all used satisfactorily at levels of 8% to 16% in cattle fattening rations. Average daily gains-feed per 100 lb. gain were as follows: Experiment I (2 steers per group fed 84 days) 12% GCC, 1.77–1088; 12% CSH, 2.71–901; 12% RH (3 replicates), 2.36–949, 2.33–965, 2.70–804; 12% BS (2 replicates), 2.26–923, 2.36–930. Experiment II (10 to 12 steers per group fed 120 days) 12%

CSH, 2.41–883; 12% RH, 2.37–838; 12% GRH, 2.44–783; 12% GPH, 2.26–801. Experiment III (11 to 12 steers per group fed 140 days) 8% CSH, 2.37–965; 12% ALF, 2.36–908; 16% DBP, 2.37–901; 16% OMF, 2.26–1000; 11% SBH, 2.30–919. Gains were not significantly different in any experiment. The above data suggest possible use of several roughages in high concentrate rations when management and nutritional requirements are adequately supplied.

224. PELLETED LOW-ROUGHAGE COMPLETE RATIONS FOR STEERS. J. L. Williamson*, H. B. Geurin, J. C. Thompson, W. S. Teter, D. K. Hotchkiss, H. L. Wilcke, and R. M. Bethke, *Ralston Purina Company, St. Louis, Missouri.*

Steers fattened on pelleted complete rations consisting only of barley and balanced supplement have gained as rapidly as, and more efficiently than, steers fed similar meal rations of steam rolled barley and balanced supplement in nine comparisons using a total of 196 steers. This contrasts with the available experiment station reports and Purina data which indicate that fattening cattle have usually gained more slowly on pelleted complete rations than on comparable meal rations when these rations included less than 50% roughage and used corn or milo as the primary energy source. Average daily gains-feed per 100 lb. gain for each comparison of barley rations in meal versus pellet form were: Meal 2.68–770, pellet 2.88–717; meal 3.06–767, pellet 3.00–736; meal 3.31–723, pellet 3.09–732; meal 2.42–836, pellet 2.60–752; meal 2.37–828, pellet 2.41–806; meal 2.52–806, pellet 2.71–745; meal 2.13–840, pellet 2.37–683; meal 2.32–840, pellet 2.20–757; meal 2.18–893, pellet 2.25–772. Averages of performance on barley rations weighted by steer days indicate average daily gains, feed per 100 lb. gain, dressing percent, and carcass grades as follows: Meal 2.47, 817, 62.7, 7.4; pellet 2.53, 743, 62.6, 7.0. (Carcass grade score: 7=Low Choice, 8=Average Choice.) These data indicate minor differences between rolled and pelleted barley rations, except for significantly ($P<.01$) more efficient utilization of the pelleted ration.

225. PROTEIN-ENERGY INTERACTION IN NUTRITION AND GROWTH OF CATTLE. Clarence F. Winchester and Walter R. Harvey, *Agricultural Research Service, USDA, Beltsville, Maryland.*

For each increment in rate of gain up to 1½ lb. daily, a level of digestible protein intake was found that permitted minimal digestible energy intake. Likewise, a level of energy intake was found for each increment of change in rate of gain that permitted minimal digestible protein intake (within the limits of the experiment). A similar interaction was found between nitrogen and energy intake in relation to nitrogen retention. Data on 42 pairs of monozygotic twin beef-type cattle were used to determine the protein-energy interaction; the nitrogen retention study was based on data from 12 pairs of twins. A curve fitting procedure was employed making use of multiple regression techniques in which both interaction and curvilinear components were fitted.

226. SEPARATION OF NITROGEN FRACTIONS PRODUCED BY CELLULOLYTIC RUMEN BACTERIA GROWN ON A UREA MEDIUM. K. A. Winter*, B. A. Dehority and R. R. Johnson, *Ohio Agricultural Experiment Station, Wooster.*

Previous *in vitro* rumen studies in this laboratory showed that after fermentation a considerable portion of the N was in an unknown non-protein nitrogen (UNPN) form. In the study of N metabolism by rumen bacteria it was of interest to identify this and other nitrogenous fractions synthesized from non-protein nitrogen. Cellulolytic rumen bacteria were grown in a medium of minerals, growth factors, cellulose and urea. After 24 hours fermentation the flask contents were analyzed for total-N, NH_3-N, urea-N and protein (trichloroacetic acid (TCA) insoluble-N). The means for these fractions over six fermentations were 64.1, 14.9, 1.0, and 25.4 mg. respectively per 100 ml. flask, leaving 22.9 mg. of UNPN. When the cell fraction of the flask contents was separated by centrifuging and washing, the flask contents were dialyzed against water, subjected to disintegration by sonic oscillation or a protein isolation technique, the protein-N was lowered to 15.6, 13.0, 9.7 and 20.9 mg. respectively per 100 ml. of flask contents. Protein values determined by the biuret method on the TCA precipitates were similar to the Kjeldahl values, except for direct precipitation of the flask contents which gave turbid solutions. These data on the protein fraction suggest that direct precipitation with 10% TCA yields a high value as a result of co-precipitation of NPN fractions which are not precipitated following the various treatments outlined above. This also suggests that the actual UNPN fraction is higher than previously observed. Further analysis of this fraction for amides, hexosamines, amino acids and other organic-N compounds will be reported.

227. INFLUENCE OF VARIATIONS IN THE DIETARY CA:P RATIO ON PERFORMANCE AND BLOOD CONSTITUENTS OF CALVES. M. B. Wise*, E. R. Barrick and A. L. Ordoveza, *North Carolina Agricultural Experiment Station, Raleigh.*

Forty-five Hereford calves were used in a factorial experimental design with three levels of calcium (0.27, 0.81 and 2.43% of the diet) and three levels of phosphorus (0.17, 0.34 and 0.68% of the diet). The nine resulting calcium:phosphorus ratios ranged from 0.4:1 to 14.3:1. Levels and ratios of Ca and P were effected by addition of varying amounts of calcium carbonate, defluorinated rock phosphate and dibasic sodium phosphate to a semi-purified diet based on degerminated corn meal, starch, cerelose, urea, blood meal, beet pulp, corn oil, minerals and vitamins. The calves were individually fed, *ad libitum* over a period of 98 days for the first two replications and 112 days for the last three replications. Considering all five replications, performance and nutrient conversion were markedly decreased with Ca:P ratios lower than 1:1. Ratios between 1:1 and 6:1 gave similar and satisfactory results. Ca:P ratios above 6:1 resulted in decreased performance and nutrient conversion values, but adverse effects were not as marked as with the ratios below 1:1. Several significant trends were evidenced in serum inorganic phosphorus, magnesium and phosphatase activity attributable to

levels and ratios of dietary calcium and phosphorus. One of the most interesting of these observations was that serum magnesium levels were decreased with high levels of dietary phosphorus when dietary calcium levels were low. Diets with high calcium levels resulted in a "normal" serum magnesium level even at the highest phosphorus level.

228. INVESTIGATIONS ON THE FEEDING OF ALL-CONCENTRATE RATIONS TO BEEF CATTLE. M. B. Wise*, T. N. Blumer, E. R. Barrick and G. Matrone, *North Carolina Experiment Station, Raleigh.*

Previous work at the N. C. Agricultural Experiment Station has shown that calves will perform satisfactorily on a basal diet of ground shelled corn, urea, cottonseed oil, minerals and vitamins. Daily weight gains, nutrient conversion and characteristics indicating carcass quality were not improved by adding hay in either ground or long form. Two additional all-concentrate experiments have been conducted. In the first experiment, 24 Hereford calves averaging 395 lb. each were divided into four groups on the basis of weight within sexes (three replications of steers and three replications of heifers). One ration was based on ground shelled corn, urea, cottonseed oil, minerals and vitamins (Urea Basal). In a second ration the urea was replaced with soybean oil meal so that protein levels were equal (SBOM Basal). A third ration consisted of the SBOM Basal + 5% Na + $KHCO_3$ (SBOM Basal + Na + K). A fourth ration consisted of the SBOM Basal + 5% $CaCO_3$ (SBOM Basal + Ca). All rations were individually fed, *ad libitum*, over a period of 224 days. Average daily gains, daily feed intake and feed per unit gain were respectively: *Urea Basal*—1.54, 9.65, 6.37; *SBOM Basal*—1.60, 11.04, 7.09; *SBOM Basal + Na + K*—1.62, 11.85, 7.55; *SBOM Basal + Ca*—1.78, 11.85, 6.79. In a second experiment, 40 steers averaging 675 lb. initially were divided into 4 groups of 10 each and fed *ad libitum* a basal ration consisting of 90% ground shelled corn, 6% SBOM, 2% animal fat, 1% limestone, 1% TM Salt and Vitamins A and D. The 98-day average daily gains for treatments were as follows: *Basal*, 3.12; *Basal + 5% $CaCO_3$*, 2.87; *Basal + 3 lb. hay daily*, 3.11; *Basal + hay ad libitum*, 3.24. No problems with diarrhea, bloat or stiffness have been encountered. Carcass evaluation data will be presented.

229. SOME BIOCHEMICAL CONSTITUENTS IN URINE OF VITAMIN A DEFICIENT HOLSTEIN CALVES. C. G. Woelfel*, M. C. Calhoun, J. E. Rousseau, Jr., H. D. Eaton, S. W. Nielsen and E. J. Kersting, *Storrs (Conn.) Agricultural Experiment Station, Storrs.*

Thirty Holstein male calves, 53±6 days of age, 158±19 lb. of live wgt., and 6.2±3.7 mcg. of plasma vitamin A, were fed for a 16-wk. comparison period a vitamin A depletion ration at a level of intake to provide an anticipated 7-day increase in live weight of 10 lb. and either a deficient or adequate carotene intake, 15 or 150 mcg. per lb. of live weight daily, from artificially dehydrated alfalfa. Deficient calves consumed slightly less vitamin A depletion ration allowance accompanied by smaller daily gains in live weight. In the terminal portion of the comparison period, deficient calves had significantly greater cerebrospinal fluid pressures than the adequate calves, but no significant differences existed in intraocular pressures determined either manometrically or tonometrically and in average arterial (carotid) blood pressure. Specific gravity, osmolaiity and concentration of total solids of urine for 24-hour collection periods, were significantly less in the deficient calves. Concentrations and 24-hour outputs of urea nitrogen and creatinine were less in the deficient calves, but not statistically significant. In an attempt to ascertain the constituent(s) responsible for the reduced urinary solutes in the deficient calves, repeat collections were made. In five deficient calves osmolality was less (93%), as well as sodium and chloride concentrations (81 and 84%) and daily output of these minerals (86 and 92%) than in five adequate calves. Potassium concentration was slightly less but daily output was essentially the same.

230. POST-PARTUM REPRODUCTIVE PERFORMANCE IN BEEF HEIFERS AS AFFECTED BY PROTEIN AND ENERGY INTAKE DURING GESTATION. D. R. Zimmerman*, D. C. Clanton, J. K. Matsushima, *University of Nebraska, Lincoln.*

Thirty-two bred yearling Hereford heifers were allotted in equal numbers to four ration treatments (Low Protein-Low Energy, LL; Low Protein-High Energy, LH; High Protein-Low Energy, HL and High Protein-High Energy, HH). The low levels of protein and energy were calculated to provide for maintenance only, while the high levels were designed to provide 150% of the protein and energy required for maintenance. These diets were individually fed to heifers in proportion to their body weight during a 140 day wintering period. The heifers were allowed 3 lb. of corn and a full feed of alfalfa hay during the summer following calving. Heat checks were made with a sterilized bull. Palpations were made at weekly intervals for ovulation and involution of the uterus and during the sixth and ninth weeks post-breeding for pregnancy. The heifers were bred on the first heat after 75 days post-calving. Restricting energy intake during the winter significantly increased the interval from calving to first heat (142 and 148 days for the LL and HL groups vs. 54 and 51 days for the LH and HH groups); restricting protein intake failed to influence it. The time of uterine involution was delayed when both protein and energy were restricted but no effect was apparent when either nutrient was restricted alone (74 days for the LL group vs. 54, 56 and 52 days for the LH, HL and HH groups, respectively). Only the LH and HH cows provided sufficient data for a fertility comparison since the number of cows in the LL and HL groups which cycled during the time allowed for breeding was too small (3 LL and 2 HL cows) to establish the fertility of the groups. The LH cows appeared to be more difficult to settle than the HH cows (38 vs. 83% conception on first service).

231. CALCIUM AND PHOSPHORUS LEVELS FOR BABY PIGS. D. R. Zimmerman*, V. C. Speer and V. W. Hays, *Iowa State University, Ames.*

One-hundred forty-four baby pigs (fed from 3 to 7 weeks of age) were used to study the Ca

(calcium) and P (phosphorus) requirements in a high milk-product ration (25% dried skim milk equivalent and 0.1% phytin P). A 4 x 4 factorial arrangement of 0.4, 0.5, 0.6 and 0.7% total P and 0.50, 0.65, 0.80 and 0.95% Ca in the ration was used with randomized incomplete blocks arranged in such a way that one-third of the Ca × P interaction was confounded. The criteria of performance were bodyweight gain, feed efficiency and percent ash of surgically removed metatarsals. In regard to gains, the Ca × P interaction was highly significant. Ca:P ratios greater than approximately 1.6:1.0 suppressed the growth rate. Also, P at 0.40% of the ration was inadequate for maximum gains regardless of the Ca level. Increasing the P level significantly improved feed utilization, and conversely, increasing the Ca level significantly decreased the same. Therefore, efficiency of feed utilization became progressively poorer as the Ca:P ratio widened. The treatment effects on percent metatarsal ash were additive and significant. Percent ash was increased by increasing levels of either Ca or P.

232. PROTEIN REQUIREMENT AND PROTEIN-ENERGY INTERRELATIONSHIPS IN BEEF CATTLE FINISHING RATIONS. J. E. Zimmerman*, F. K. Deeble, and A. L. Neumann, *University of Illinois, Urbana.*

Four lots of eleven heavy Hereford-Angus crossbred steer calves (average of 10 months of age and 555 lb.) were used in a 168-day feeding trial to study two levels of energy (68 and 75% TDN) and two energy-protein ratios (5.9 and 7.2 lb. TDN per lb. crude protein). The basal ration was composed of corn silage, cracked shelled corn, and soybean meal. The energy level was changed by changing the ratio of corn silage and shelled corn. The energy-protein ratio was varied by substituting soybean meal for shelled corn. Average daily gains (lb.) and TDN intake per lb. of gain (lb.) were as follows: Lot I (low energy, wide ratio), 1.86, 7.03; Lot II (low energy, narrow ratio), 2.04, 6.52; Lot III (high energy, wide ratio), 1.84, 7.38; and, Lot IV (high energy, narrow ratio), 2.10, 6.56. Lot II and IV gained significantly faster ($P<.01$) than Lots I and III. Response to the narrow energy-protein ratio was greater during the first half of the trial than during the second half, suggesting that with increased age a wider ratio was adequate. Feed consumption was approximately equal for lots receiving the same energy level.

233. NUTRITIVE VALUE OF DEHYDRATED SORGHUM SILAGE. W. B. Anthony*, L. A. Smith, V. L. Brown, and R. R. Harris, *Auburn University Agricultural Experiment Station, Auburn, Alabama.*

An earlier report from this Station (J. A. S. 18:1506, 1959) stressed the high nutritive value of dehydrated and pelleted silages. In the present study Sart sorghum was harvested for silage at three stages of maturity, namely: (1) immature—no head (I); (2) early head (EH); and (3) full head and grain in dough (M). For feeding, lots of these silages were dehydrated and pelleted. Nutrient balance data were obtained using six Hereford steers in a 3 x 3 latin square design. Preliminary feeding proved it necessary to feed a protein supplement in order to keep cattle on feed. Therefore, in all trials, each animal received daily 1.5 pounds of soybean meal plus pelleted silage. Metabolizable energy values (%) for (I), (EH) and (M) were, respectively, 51.55, 50.01 and 47.15 (differences were significant). Among the major nutrients, cellulose digestibility showed the greatest decline with advancing maturity. Cellulose digestion coefficients for (I), (EH) and (M) were 64.29, 52.49 and 44.80, respectively. Sugar and starch digestibility showed no change relative to stage of maturity, but sugar and starch contents increased slightly with plant maturity. Mineral content and mineral retention were not influenced by stage of maturity. These data indicate that delaying harvest of Sart sorghum silage until the grain head is filled out materially lowers overall nutritive value. Cellulose is the nutrient most adversely affected by plant maturity. Contrary to results reported in 1959, cattle did not relish the pelleted silage.

234. EARLY WEANING AND OTHER METHODS OF INTENSIVE LAMB PRODUCTION. L. Cesana*, R. C. Carter, F. S. McClaugherty, J. S. Copenhaver, and R. E. Blaser, *Virginia Agricultural Experiment Station, Blacksburg.*

Experiments in early weaning and other methods of intensive lamb production were conducted in 1960 and 1961 at the Blacksburg and Glade Spring Stations. All treatments were started in late April at the beginning of the grazing season. Grade Hampshire, Dorset, Suffolk and North Country Cheviot lambs averaging 58 lb. in weight and 82 days of age (born January to March) were used as test animals. Treatments were as follows: (1) Control—ewes and lambs grazed together continuously on bluegrass; (2) and (3) lambs weaned and grazed rotationally on bluegrass or ladino clover respectively; (4) and (5) lambs not weaned but grazed separately from ewes on bluegrass or ladino clover; (6) and (7) lambs weaned in dry lot on low or high roughage pelleted rations; (8) and (9) lambs not weaned but in dry lot on same pelleted rations as (6) and (7). Not all treatments were duplicated in both years or at both Stations. Average daily gains at Blacksburg by treatments for 1960 and 1961 respectively were: (1) 0.44–0.51; (2) 0.48–0.44; (3) 0.55–0.43; (6) none–0.70; (7) none–0.65. At Glade Spring daily gains by treatments and years were: (1) 0.61–0.54; (4) 0.66–0.51; (5) 0.75-none; (6) none–0.62; (7) none–0.57; (8) none–0.63; (9) none–0.65. Slaughter and carcass grades and dressing percents generally ranked in the same order as daily gains.

235.

236. THE CALORIC EQUIVALENT OF THE FORAGE NUTRITIVE VALUE INDEX. E. W. Crampton*, E. Donefer and L. E. Lloyd, *Macdonald College (McGill University), Quebec, Canada.*

A Nutritive Value Index (NVI) that numerically describes the effective feeding value of forages has been previously described (J. A. S. 19: 538, 1960). Subsequent studies have revealed that the gross energy of the dry matter of common forages is 4.5 Calories per gm., and that this value does not differ appreciably between botanical species nor as a consequence of differences in stage of maturity or in proximate composition. For practical purposes the

gross energy of forage dry matter can be taken as a constant, and a factor computed for calculating the coloric equivalent of NVI. The 24-hour Digestible Energy (Cal.) intake for sheep = NVI × $W_{kg}^{.75}$ × 3.6; the factor for cattle (average weight, 1000 lb.) is 6.3.

237. FORAGE CELLULOSE SOLUBILITY AS AN ESTIMATE OF CELLULOSE DIGESTIBILITY AND NUTRITIVE VALUE OF FORAGES. Burk A. Dehority* and Ronald R. Johnson, *Ohio Agricultural Experiment Station, Wooster.*

A method has been developed to determine the amount of cellulose in a forage which can be dissolved by cupriethylene diamine. Thirty ml. of cupriethylene diamine (0.5 M. in copper) was added to 0.6 gm. forage; placed on a shaker for two hours, the residue separated by centrifugation and washed twice with 15 ml. quantities of cupriethylene diamine and analyzed for residual cellulose. Such factors as shaking time, solvent concentration and size of the forage particle were investigated. Using four stages of timothy and three stages each of brome and orchard grass, the amount of cellulose dissolved decreased as the forage matured. The percent of forage cellulose dissolved was linear and highly correlated with the percent of cellulose digested in the *in vitro* rumen fermentation. Comparisons of the solubility data with *in vivo* cellulose digestion for 12 grass samples and effective nutritive value index for 8 grass samples showed marked linear associations. Attempts to correlate cellulose solubility of alfalfa with *in vitro* and *in vivo* cellulose digestion were unsuccessful, suggesting a difference in the structure of grasses and legumes.

238. EFFECT OF SEVERAL VARIABLES ON THE *IN VITRO* DIGESTION OF FORAGE CELLULOSE. E. Donefer*, L. E. Lloyd, and E. W. Crampton, *Macdonald College (McGill University), Quebec, Canada.*

Cellulose digestion of red clover, timothy, oat straw, and Solka Floc substrates was determined after a 12-hour fermentation period, according to the *in vitro* method previously described (J. A. S. 19: 545, 1960). Two inoculum donor steers were fed alternately alfalfa and timothy hay, with no difference observed in cellulolytic response from inoculum prepared from either steer when fed the same forage. Either phosphate buffer extract (P.B.E.) inoculum prepared from solid rumen ingesta or resuspended cell (R.C.) inoculum prepared by supercentrifugation of the P.B.E., ranked the forages in the same relative order of nutritive value. R.C. inoculum prepared from steers fed timothy hay showed an overall lower cellulolytic activity than other combinations of source and type of inoculum. The digestion of Solka Floc cellulose was much more effected by source and type of inoculum than were any of the forage substrates. In a second series of *in vitro* tests, the effect of casein hydrolysate (C.H.) supplementation of the nutrient medium was determined with alfalfa, red clover, timothy, and Solka Floc substrates using the same sources and types of inoculum as in the previous series. Of the forage substrates, only timothy cellulose digestion was stimulated by C.H. supplementation and only when R.C. inoculum was used. Maximum digestion occurred with this substrate with or without supplementation when P.B.E. inoculum was used. Solka Floc digestion by R.C. inoculum was increased two- to three-fold with casein hydrolysate addition, but was still below the level achieved with P.B.E. inoculum.

239.

240. GRAZING BEHAVIOR OF RANGE BEEF COWS. R. D. Furr* and A. B. Nelson, *Oklahoma State University, Stillwater.*

The behavior of a total of 49 range beef cows grazing native grass pasture was observed continuously in five 24-hour periods. The number of individual cows observed per study varied from 7 to 11, and cows were suckling calves in three of the studies. Cows spent an average of 600, 539, and 274 min., or 42, 37, and 19%, of the 24-hour period grazing, ruminating, and idling, respectively. Three primary periods of grazing were usually (1) near daybreak, (2) afternoon and/or evening, and (3) near midnight. Temperature changes and quality of forage apparently altered the total time spent grazing. Time between primary grazing periods was devoted mainly to ruminating and idling. A greater percent of the total ruminating time was at night than during the day. Cattle spent more time ruminating in a lying position than when standing (25.6 vs. 11.9%). More idling was in the standing position than when lying (10.8 vs. 8.2%). In 24 hours, the cattle traveled an average of 2.59 miles, defecated 5.6 times and urinated 2.4 times. The calves usually nursed three times during a 24-hour period for a total of 23 minutes. Continuous observations in all five studies were compared with observations at 15-, 30- and 60-minute intervals. Reasonably accurate estimates of grazing and ruminating time were obtained at 15- and 30-minute intervals of observation. Observations at 15-minute intervals did not appear to be adequate for reliable estimates of such minor activities as walking, sleeping, nursing calves, defecation, urination, and drinking.

241. SOURCES AND LEVELS OF PROTEIN AND ENERGY FOR WINTERING STEERS FOLLOWED BY DIFFERENT FATTENING SYSTEMS. Edwin E. Goodwin*, Johnny H. Davis, Barton Farthing, and S. L. Hansard, *Louisiana State University, Rice Experiment Station, Crowley.*

In a 6 x 3 split block experiment, six wintering rations followed by three fattening systems were tested in four replicates with 72 Hereford x Brahman steer calves averaging 395 lb. initially. Phase I (64 days) rations, weight gains, and feed ingredient costs per head, were, respectively: A. Rice straw (RS, ground, self-fed) plus 1 lb. cottonseed meal (CSM), 25.3 lb., $6.08; B. RS plus 2 lb. CSM, 43.3 lb., $8.06; C. RS plus 3 lb. commercial cattle protein cubes, 32.1 lb., $9.02; D. Sart sorghum silage (S) plus ½ lb. CSM, —33 lb., $5.95; E. S plus 1 lb. CSM, 18.1 lb., $7.81; F. Complete ration self-fed, 96.1 lb., $16.57. Phase II (89 days) treatments were: A. Complete ration self-fed in drylot; B. ryegrass-clover pasture replicated and rotated; C. pasture as B plus milo full-fed. Phase II responses, inversely proportional to Phase I, largely overshadowed differences ($P < 0.01$) in Phase I effects on total weight gain and live grade. Drylot steers (II A) gained 283 lb./head,

on 620 lb. feed (ingredient cost $12.40) per cwt. gain; II B gained 183 lb./head (pasture cost $6.56/cwt. gain); and II C gained 199 lb./head (pasture and milo cost $7.33/cwt. gain). Drylot steers were significantly higher than pasture-fattened steers in weight gain, shipping shrinkage, and live grade ($P<0.01$). Milo increased pasture carrying capacity markedly and apparently raised average grade from standard plus to good minus, approaching statistical significance. Some approximated returns/head over initial plus feed costs were: II A, $27; II B, $23; and II C $32; among the 18 combinations, I D followed by II A returned only $18/head.

242. COMPARISON OF FORAGE EVALUATION SYSTEMS. W. A. Hargus*, M. A. Love and W. H. Pfander, *University of Missouri, Columbia.*

Two experiments involving 112 individual metabolism trials and 25 total animal body energy determinations were conducted with lambs to compare different forage evaluation techniques. The systems studied were total digestible nutrients, digestible energy, metabolizable energy, productive energy (determined by comparative slaughter) and animal performance. The first experiment involved four rations having widely different ratios of soluble to insoluble carbohydrate. Increasing the non-soluble carbohydrate decreased ($P>.01$) protein and dry matter digestibility, DE/lb. of feed, %TDN, %DE, and % cellulose digestion but increased ($P>.05$) grams of cellulose digested per day. Increased soluble carbohydrate decreased ($P>.01$) both % cellulose digestion and grams of cellulose digested per day. The forages used in the second experiment were alfalfa (first and third cutting), orchard grass, timothy and fescue fed in both the chopped and pelleted form. Supplemental minerals and vitamins were added to all pelleted rations and 6.5% purified protein was added to the pelleted grass hays. Lambs fed pelleted forages ate more, gained faster, had better feed efficiencies and different nutritize value index patterns than those fed chopped forages. The data indicated that productive energy may be superior to TDN and DE in forage evaluation.

243. SEASONAL YIELDS AND PALABILITY OF ELEPHANT GRASS. Roux Héctor, Muñoz Héctor, and Arthur T. Semple*, *Inter-American Institute of Agricultural Sciences.*

Two experiments were carried out from 1959 through 1961. Two cutting frequencies and two fertilizer levels were used to measure the effects of fertilization and cutting frequency. Data taken includes: green and dry matter yields, plant height, width of leaf, distance between nodes, number of nodes, stem diameter, percent of stems and leaves, and palatability. Rainfall, hours of sunlight, temperature and evaporation were utilized in the analyses of the experiment. Statistical analysis showed that fertilization increased green and dry matter yields, protein and fiber percents, and morphological measurements. Fertilization decreased the percentage of ash but did not affect ether extract percent. Longer cutting intervals (8 weeks) produced higher green and dry matter yields. The morphological measurements, with the exception of leaf percent, also increased. Protein percent decreased as the percent of dry matter and fiber increased. There were no statistical differences in the consumption of 6 and 8 week old forage on either a green or dry basis. Based on green forage consumption the differences were not significant betwen the two levels of fertilization. However, on a dry matter basis, consumption of non-fertilized forage was significantly higher than that of fertilized. Green and dry matter yields varied enormously during the year. Similar differences were found in the morphological measurements and consumption of forage by steers.

244. USE OF THE DACRON BAG TECHNIQUE AS AN ESTIMATE OF THE RATE OF *IN VIVO* CELLULOSE DIGESTION IN THE EVALUATION OF FORAGES. James D. Hopson*, Ronald R. Johnson and Burk A. Dehority, *Ohio Agricultural Experiment Station, Wooster.*

The rates of cellulose digestibility of alfalfa, brome grass and a first and second cutting of timothy hay were determined *in vivo* with four yearling, rumen fistulated, wether lambs by means of the dacron bag technique. Experiment I consisted of a time trial with samples taken after 6, 12, 18, 24, 30, 36 and 42 hours in the rumen. The rates of cellulose digestion were compared with the cellulose digestibilities as determined by a conventional digestion trial involving four lambs in a 4 x 4 Latin square design. The material placed in the dacron bags was a representative sample of the same ration fed the sheep during each phase. The results showed that the 36- and 42-hour time samples were the only ones that had a significant correlation to the digestibility coefficient of cellulose in a conventional digestion trial. Significant differences in rates of digestion were found between alfalfa, brome and the two timothies. Digestion of cellulose in alfalfa hay could be detected earlier than with the grass hays with maximum digestibility of alfalfa occurring 6–12 hours sooner, indicating a more rapid rate of digestion for alfalfa as compared to the grass hays. Experiment II was carried out to discover the effect, if any, of feeding the lambs a forage different from the forages in the dacron bags. The bags were removed from the rumen at 9 and 15 hours. A significant difference in cellulose digestion of all 4 forages in the dacron bags existed when alfalfa was used as the animal's ration as compared to the grass hays. There were no significant differences between the effects of the 3 grass hays on any of the forage digestibilities in the bags.

245. FESCUE TOXICITY. Don R. Jacobson* and Wm. M. Miller, *University of Kentucky, Lexington.*

Continuing studies on the nature of the toxicity have revealed that it is distinct from the typical ergot toxicity. It has occurred as early as 8 days or as late as 6 months after the animals were placed on fescue pasture and on pasture in which no seed heads and no sclerotia of *Claviceps purpurea* were present. In some 50 mild to severe cases, clinical observations on experimental pastures included an unsteady gait or lameness, which was slight or marked and may even disappear during the toxicity; slight to rapid loss of body weight, with emaciation; arched back; dull appearance; long rough hair coat; partial or complete loss of hair from the tail and dry gangrene in the extremity of the tail, and/or legs which may be sloughed away only after several weeks delay;

eruption or lesions on the legs (primarily between hocks and claws of rear legs); and irregular hoof and horn growth. Recovery from all symptoms except gangrene and hoof-horn growth appeared to be spontaneous within a few days after removing the animals from the forage. During periods of high environmental temperature, body temperature and respiration rate was increased above controls and the tendency for gangrene to develop was reduced. The evidence indicates that a vasoconstriction of the skin and extremities is involved.

246. DISCREPANCIES BETWEEN GRASSES AND LEGUMES WHEN ESTIMATING NUTRITIVE VALUE OF FORAGES BY *IN VITRO* TECHNIQUES. Ronald R. Johnson*, B. A. Dehority and H. W. Scott, *Ohio Agricultural Experiment Station, Wooster.*

The *in vivo* cellulose digestibilities and effective nutritive value index (ENVI) of four grasses cut at two stages of maturity and alfalfa cut at three stages were compared with *in vitro* cellulose digestion at 12, 24 and 48 hr. Correlation coefficients for the three fermentation periods with ENVI were 0.95, 0.94 and 0.92, respectively, when only the grasses were considered, but were 0.86, 0.54 and 0.37, respectively, when alfalfa was included in the correlation. *In vitro* cellulose digestibility was highly correlated with *in vivo* cellulose digestibility at all three time periods for the grasses but only at the 48 hour fermentation time when alfalfa was included in the analysis. Using the chromic oxide technique with grazing dairy cows, the dry matter digestibility of a series of mixed forages (alfalfa-brome) harvested at different periods of the season were compared to 12-hour *in vitro* cellulose digestibilities of the forages in both the fresh and dried state. The correlation coefficients were 0.82 and 0.60 for the fresh and dry, respectively. When *in vitro* cellulose digestion of the fresh and dry samples were compared, the fresh samples were significantly more digestible at 12 hours than the dry samples, suggesting that determinations of nutritive value of fresh forages (pasture or soilage) may have to be made on fresh samples, or a correction factor applied to dried samples. The technique for handling fresh forages in *in vitro* digestion trials will also be discussed.

247. DETERMINATION OF FORAGE HOLOCELLULOSE DIGESTIBILITY BY *IN VITRO* FERMENTATIONS. L. D. Kamstra* and M. M. Thurston, *South Dakota State College, Brookings.*

Samples of alfalfa-brome, sweet clover-rye, soybean-sudan and native prairie grass (primarily western wheat) were collected from enclosures at shoot, pre-bloom and late bloom stages. Five clippings were made from the grazed area outside the enclosures, with first, third and fifth clippings corresponding to the sample collection dates of forage inside the enclosures. Holocellulose was isolated by the chlorite method from these samples taken during two growing seasons. The digestibility of holocellulose and cellulose within holocellulose and intact plant samples was determined by *in vitro* digestions. Digestibility of the entire holocellulose fraction was obtained by chlorite reisolation of the fraction from the digestion residue following a 48-hour *in vitro* fermentation. The digestibility of the entire fraction was greater than the cellulose portion of the holocellulose and cellulose within intact plant samples. For example, the digestibility of the holocellulose fraction isolated from alfalfa-brome was 81.2, 64.0 and 61.6 for the first, second and third stages respectively. The digestibility of cellulose within holocellulose was 73.8, 61.3 and 58.1 and within the intact plant 76.8, 60.6 and 51.0 during the same *in vitro* digestion period. These results would suggest that hemicelluloses are more digestible components of holocellulose than cellulose. Clipped forage holocellulose decreased in digestibility during mid-season and increased again in late season, while forage stages, with few exceptions, decreased in digestibility with each stage.

248. DIGESTIBILITY OF GRASS SILAGES PRESERVED WITH BACITRACIN AND CORN. P. E. Loggins*, Diego Gandara, C. B. Ammerman and J. T. McCall, *University of Florida, Gainesville.*

The digestibility of Coastal Bermudagrass, Pangolagrass and Pensacola Bahiagrass was determined with sheep. Three treatments were used: (1) no preservative (control), (2) 5 gm. of zinc bacitracin per ton of fresh forage, and (3) 5 gm. of zinc bacitracin plus 150 lb. of ground snapped corn per ton of fresh forage. Two 7-day collection periods were used in a 3 x 3 factorial replicated design with the same animals and treatments. Fifteen crossbred Native-Rambouillet wethers were randomly alloted into three groups of five each for the study. Digestion trials were of the conventional total collection type. The Coastal Bermudagrass silages were not significantly different in protein digestibility. Coastal Bermudagrass silage treated with the antibiotic plus 150 lb. of ground snapped corn was significantly higher ($P<0.01$) in the digestibility of dry matter. Total digestible nutrients of Coastal Bermudagrass silage treated with the antibiotic alone was significantly lower ($P<0.01$). Pangolagrass silage treated with the antibiotic alone was significantly higher ($P<0.01$) in the digestibility of dry matter and protein when compared with the other two treatments. The Pangolagrass silages were not significantly different in total digestible nutrients. Pensacola Bahiagrass silage treated with the antibiotic alone was significantly higher ($P<0.01$) in the digestibility of protein, dry matter and total digestible nutrients when compared to the other two treatments. Further observations determined on the silages will be presented.

249. THE MODE OF ACTION OF PENICILLIN IN PREVENTING LEGUME BLOAT. W. M. Miller* and D. R. Jacobson, *University of Kentucky, Lexington.*

Previous work at this station has shown that dairy animals receiving penicillin while grazing a bloat-producing legume do not exhibit any great shifts in the microbial population of the rumen. Observations during the 1960 grazing season indicated that penicillin treated animals had lower stable Ingesta Volume Increase values. Results obtained during the 1961 season have substantiated this observation. From manometric determinations on rumen contents of animals stall-fed fresh chopped succulent alfalfa, it was observed that control animals produce about one and a half times as much gas as those receiving

penicillin. In preliminary calculations, the average gas production, in mm. Hg. pressure increase per minute over a 90-minute period, of rumen contents from the penicillin-administered animals was found to be 0.53 as compared to 0.80 for the controls. Pencillin disappeared rapidly (within 1 hour) from the rumen after the animals had been on the antibiotic for 10 to 12 days. The data show that penicillin exerts its bloat preventive effect by reducing fermentation rate of the rumen microorganisms. This in turn leads to a reduced rate of stable froth formation in the rumen and a lowered incidence of bloat.

250. EFFECT OF A CONTINUOUS SUPPLY OF UREA ON UTILIZATION OF LOW QUALITY FORAGES. D. J. Minson and W. J. Pigden*, *Animal Research Institute, Research Branch, C.D.A., Ottawa, Canada.*

Following reports from N.I.R.D., Shinfield, that continuous infusion of urea into the rumen of cattle fed oat straw increased consumption 40% and D.M. digestibility 9%, the effect of continuously administered urea on utilization of straws under various feeding regimes was further studied. In Exp. 1, sheep were fed, every 90 min., a ration of pelleted wheat straw (0.6%N) containing 2% urea, sodium sulphate and a commercial mineral mixture. In Exp. 2, sheep were fed chopped wheat straw and drenched every 90 min. with an aqueous solution containing 1 gm. urea. In Exp. 3, steers were fed chopped oat straw (0.5%N) either for 4½ hrs. daily or the straw was available at all times. Urea (150 gm./animal/day) was continuously infused in aqueous solution through rumen fistulas. Urea had no consistent effect on digestibility coefficients for D.M., energy, crude fibre and N.F.E. but depressed consumption by 12, 15 and 12% in Exp. 1, 2 and 3 respectively. In Exp. 3, length of time straw was available had no effect on response to urea. The reason why these results differ from the British work is at present unknown.

251. DIGESTIBILITY, CONSUMPTION, AND MILK PRODUCTION BY COWS FED LOW MOISTURE (43%) VS. WILTED (68%) GRASS SILAGE AS THE ONLY ROUGHAGE. R. P. Niedermeier*, B. R. Baumgardt and C. E. Zehner, *University of Wisconsin, Madison.*

Alfalfa-brome mixture was cut early and ensiled in twin 14 in. x 55 in. concrete stave silos after wilting to approximately 43% and 68% moisture levels. The chemical quality of the low moisture (43%) and wilted (68%) silages respectively was: ph—5.0, 4.5; crude protein—20.8, 19.6%; ammoniacal nitrogen as % of total nitrogen—7.35, 16.5. Silages were free of spoilage and rated high on basis of organoleptic observation. Digestibility with dairy steers for the respective silages was: Dry matter—57, 58.3%; Protein—60.9 and 63.7%. Two 16-cow groups were used in a double reversal feeding trial to compare dry matter intake and milk production on these silages. Silage was the only roughage and supplied about 75% of total D.M. intake. Cows fed the low moisture silage ate 2.2 lb. silage D.M. per 100 lb. body weight daily as compared to 1.8 lb. for the wilted silage. They produced 42.4 lb. of F. C. M. daily as compared to 40.0 lb. for those fed wilted silage. Low moisture silage fed cows averaged 0.6 lb. daily gain as compared to 1.0 lb. for those fed wilted silage.

252. THE EFFECT OF STAGE OF MATURITY OF GULF RYEGRASS ON INTRARUMINAL FATTY ACID RATIOS OF SHEEP. Paul F. Parks*, Marvin E. Riewe, H. O. Kunkel and Carl M. Lyman, *A. & M. College of Texas, College Station.*

Gulf ryegrass harvested at nine stages of maturity from March 16 to May 24, 1960, was fed to mature wethers in individual digestion crates during a conventional digestion study. Each hay was finely ground, pelleted and fed to two animals. At the end of each experiment, rumen samples were collected from the sheep via a stomach pump four hours after feeding. These samples were analyzed by gas-liquid chromatography for the molar percentages of acetate, propionate, and butyrate. This was done in order to test the thesis that intraruminal ratios of acetate: propionate:butyrate are affected by changes in the nutritive quality of the forages. Intraruminal molar ratios of acetate:propionate:butyrate produced by the forages were found to range from 59:29:12 for the initial cutting to 81:16:3 for the final cutting. There was a generally graded increase in acetate and decrease in propionate and butyrate with increasing maturity of the ryegrass. The digestible energy content of the forages correspondingly ranged from 3,114 kcal./kg. to 1,943 kcal./kg. with increasing age of the forages. The forages were analyzed for total water soluble reducing substances (TRS), expressed as glucose, in an attempt to relate this shifting acid ratio in the rumen to some chemical characteristic of the hay. The TRS was found to range from 13.4% for the earliest stage to 1.1% for the last stage. The decreasing TRS content was significantly correlated to the molar percentage of propionate plus butyrate ($r=0.735$; $P<.05$), and to the digestible energy content ($r=0.964$; $P<.01$).

253. EFFECT OF ANTHELMINTICS, HEXESTROL IMPLANTS, AND HOURS ON PASTURE ON GRAZING LAMBS. John C. Rea* and C. V. Ross, *University of Missouri, Columbia.*

Forty-four lambs were equally divided into four outcome groups and randomly assigned to one of four lots for treatment. Treatments compared were: continuous versus daylight grazing, copper sulfate versus phenothiazine drench for lambs, and Hexestrol versus no hexestrol implants for lambs on pasture. Half of the lambs in each lot were randomly selected for implantation with Hexestrol. Wethers received a 6-mg. and ewes a 9-mg. pellet. Each week from the start of the test a pellet was removed from one lamb in each lot to observe the condition and amount of encapsulation of the pellet. The lambs were grazed on two similar Korean lespedeza pastures and were rotated weekly. Lots I and II ran together on one pasture and were allowed to graze continuously. Lots III and IV ran together and were placed in drylot each night. Lambs which were allowed to graze continuously grazed earlier in the day and made 11.6% faster gains than those held in drylot at night. Lambs implanted with Hexestrol made significantly faster gains ($P<.01$) than controls even though several implanted lambs lost the pellet prior to the end of the experiment. Lambs

drenched with copper sulfate gained 0.38 lb. per day compared to 0.32 lb. for lambs receiving fine particle phenothiazine and had a slightly lower parasite infestation as measured by fecal worm egg and Hematocrit counts.

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255. EFFECTIVENESS OF ANTHELMINTICS FOR GRAZING LAMBS. C. V. Ross* and M. L. Karr, *University of Missouri, Columbia.*

Effectiveness of anthelmintics against *Hemonchus contortus* in grazing lambs was studied in two experiments involving 144 lambs. In a comparison of standard particle phenothiazine, fine particle phenothiazine (average particle size 3 microns) and 4-tert-butyl-2-chorophenyl methyl phosphoramidate (Ruelene) differences were observed within a week of the beginning of the experiment. Lambs on standard phenothiazine were less thrifty, grazed less and soon were in critical condition. At the end of 2 weeks six of 17 on that treatment actually died and most of the rest had to be removed from the pasture and given special treatment to prevent death. Lambs on fine particle phenothiazine were healthier and had a higher survival rate, but they too were unable to completely resist *Hemonchus* infection. Lambs treated with phosphoramidate (Ruelene) were much healthier, gained faster and using worm egg counts and hematocrits as criterion, were comparatively free of *Hemonchus contortus*. None died during the experiment. In a second experiment lambs treated with phosphoramidate or phosphoramidate and fine particle phenothiazine in alternate treatments made significantly ($P<.01$) faster gains than lambs treated with fine particle phenothiazine or Bephenium. Using hematocrits and worm egg counts as criterion, all treatments appeared to be effective against *Hemonchus contortus* during the experiments. Phosphoramidate appeared to be the most effective followed by the combined phosphoramidate phenothiazine treatment.

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257. INFLUENCE OF CALCIUM AND MAGNESIUM ON THE OCCURRENCE OF BLOAT IN LAMBS. Keith J. Smith* and Walter Woods, *Iowa State University, Ames.*

The effect of different minerals on the occurrence of bloat was studied using wether lambs grazing a pure stand of alfalfa during the 1960 and 1961 summer months. Lambs grazing alfalfa treated with a foliar application of magnesium carbonate (3.9 lb./acre and 7.8 lb./acre), calcium carbonate (20 lb./acre) and calcium phosphate (50.3 lb./acre) bloated more severely than lambs grazing untreated alfalfa. Lambs drenched with magnesium carbonate at the rate of 10 gm. per day, immediately prior to grazing alfalfa, bloated more severely than control lambs. The effect of magnesium carbonate applied as a foliar spray or as a drench appeared to be similar with respect to the bloat syndrome. Drenching lambs with either calcium carbonate or magnesium carbonate during the 1961 season increased the severity of bloat to a similar degree. The administration of ethylenediamine tetraacetic acid (EDTA) and diethylenetriamine pentaacetic acid (DTPA) significantly decreased the amount of bloat observed. No correlation was found between the day to day analyzed calcium and magnesium content of untreated alfalfa and the degree of bloat in lambs. The oral administration of 5 or 10 gm. of EDTA reduced the amount of ruminal ionic calcium and magnesium in lambs grazing alfalfa.

258. DIFFERENTIAL EFFECT OF LIGNIFICATION IN GRASSES AND LEGUMES ON *IN VITRO* CELLULOSE DIGESTIBILITY. Don C. Tomlin*, Burk A. Dehority, and Ronald R. Johnson, *Ohio Agricultural Experiment Station, Wooster.*

Previous work in this laboratory has shown good linear correlations between stage of maturity, lignin content, and *in vitro* cellulose digestibility for grass hays but not alfalfa. To investigate this further, pure stands were obtained of four grasses and three legumes which were sampled at pasture, early bloom, and seed stages of growth. Also, forage samples from previous years that fit the experimental outline were included in this study. Cellulose digestibility was determined *in vitro* on these samples at six, twelve, twenty-four, thirty, and forty-eight hours. Lignin was determined by an improved method developed in this laboratory. The data show a definite linear trend between stage of maturity, lignification, and cellulose digestibility for orchard, brome, and Reed canary grass hays, but the data for alfalfa, red clover, and birdsfoot trefoil suggest that maturation and lignification is at a decreased rate after bloom stage. The data for timothy indicates a linear relation between cellulose digestibility and lignin content, but that maturation and lignification do not proceed at so fast a rate as in the other grasses. The lignin-cellulose association will be discussed in reference to the differences in cellulose digstibility between grasses and legumes presently being reported by this laboratory.

259. ONCE VERSUS FIVE TIMES WEEKLY FEEDING OF SUPPLEMENTS TO EWE LAMBS GRAZING DRY RANGE. W. C. Weir*, D. T. Torell and J. H. Meyer, *University of California, Davis.*

Each year since 1956, trials have been conducted to study the most efficient and economical supplements for weanling ewe lambs grazing dry annual-grass ranges. From July to December, the lambs grazed as one flock and were gathered five days weekly for sorting into treatment groups (supplemental period). From December to shearing—late April or early May—all lambs grazed as one flock without differential treatment (recovery period). Early trials indicated that protein feeds were the most effective supplements. In 1959 the treatments included no supplement; ½ lb. per head daily of dehydrated alfalfa pellets (21.5% protein) fed once, twice, and five times weekly; and 0.214 lb. per head daily of soybean meal (50.1% protein) fed five times weekly. In 1960 treatments were no supplement; alfalfa pellets fed once and five times weekly; soybean meal fed once and five times weekly. The range forage available as sampled with esophageal fistulated sheep contained from 6.6 to 15.2% protein in 1959 and from 5.5 to 6.4% protein in 1960. In 1959, all supplements significantly improved body-weight gains during the supplemental period with

no difference between supplements. In 1960, all supplements again significantly improved bodyweight with soybean meal fed five times producing better gains than soybean meal fed once weekly. During the recovery period the unsupplemented lambs gained significantly faster both years so that there was no significant difference between treatments for the combined period in either year. Yearling grease fleece weight was improved significantly by all supplements with no difference between supplements.

260. EFFECT OF HIGH TEMPERATURE, CHLORPROMAZINE AND PROGRESTERONE UPON EMBRYONIC SURVIVAL IN THE MOUSE. J. Phillip Aldred*, Martin Stob and F. N. Andrews, *Purdue University, Lafayette, Indiana.*

Rockland-Swiss virgin female mice were subjected to 104° F. for 1, 3 or 5 hours on the day following mating, or for 5 hours on day 1 and 2 following mating. At autopsy on day 17 of pregnancy the number of corpora lutea, viable and resorbed embryos was determined, as well as ovarian, adrenal, placental, and fetal weights. There was a consistent increase in embryo loss as thermal stress was prolonged (control—14.0%; 1 hour—14.5%; 3 hours—16.8%; 5 hours—19.3%; 5 hours day 1 and 2—32.5%). Embryo mortality following high temperature exposure for 5 hours appeared greater on day 1 of pregnancy (19.3%), less after exposure on day 2 only (9.8%), and cumulative (32.5%—day 1 and 2). Chlorpromazine administration (2 mg. per kg. body weight) prior to heat exposure for 5 hours on day 1 had no effect on embryo loss (22.5%), but reduced the high mortality following thermal stress for 5 hours on day 1 and 2 from 32.5% to 16.5%. Chlorpromazine alone had no effect upon embryo survival. Progesterone treatment (1 or 3 mg. per kg. body weight) immediately prior to heat exposure for 5 hours on day 1 and 2 obviated the expected increase in embryo resorption rate (7.0% and 9.7% vs. 32.5%). Both levels of progesterone administered alone on day 1 and 2 reduced embryo loss below controls (6.9% and 8.1% vs. control—14.0%). None of the treatments significantly affected implantation rate. Rectal temperature increase averaged 3.0° F. following 5 hours of heat exposure. Chlorpromazine or progesterone did not prevent this rise.

261. HYSTERECTOMY AND OVARIAN FUNCTION IN BEEF HEIFERS. L. L. Anderson* and F. C. Neal, *Iowa State University, Ames.*

This investigation deals with ovarian function following total and subtotal hysterectomy during the luteal phase of the cycle, days 8 through 11. In four groups each consisting of four heifers the following parts of the uteri were left in the animals: Group A, none; Group B, cervix and body and in two cases the posterior portions of both horns; Group C, anterior one-fourth of the right and left horns; and Group D, anterior halves of the right and left horns. The four heifers in Group A did not show estrus during a 270-day period following the estrus prior to hysterectomy. Each animal in this group had a carbon marked corpus luteum present at slaughter indicating luteal persistence. In Group B, three estrous cycles were observed in each of three of the four heifers with the cervix and body intact. One heifer in Group B did not return to estrus during a 250-day period following the estrus prior to surgery. Histologic examination of the uterine tissues in the body and posterior parts of both horns of this heifer showed a normal endometrial epithelium. However, infiltration of leukocytes around many of the uterine glands was evident. The accumulation of fluid which distended the remaining uterine tissue may have caused an irritation upon the uterine mucosa. Endometrial epithelium was normal in three heifers in this group which did cycle after surgery and few leukocytes were evident. Three heats were observed in each of the 8 heifers in which only the anterior one-fourth of both horns (Group C) or the anterior halves of both horns (Group D) were left in the animals. These findings suggest that retrogression of active corpora lutea into corpora albicantia during non-fertile cycles in the beef heifer is dependent upon a stimulus from the uterus.

262. ADRENOCORTICAL RELATION TO LACTATION IN RATS. Ralph R. Anderson* and C. W. Turner, *University of Missouri, Columbia.*

Lactating Sprague-Dawley-Rolfsmeyer rats were adrenalectomized on the fourth day of lactation. Litters were reduced to six pups. Criteria for lactational performance were litter weights on the 4th, 14th, and 20th days of lactation, mortality rates of pups on the 14th and 20th days of lactation, and milk production on the 14th day of lactation. Experimental groups of 7 to 19 litters per group included normal lactators (16) and adrenalectomized groups as follows: (a) no treatment (15), (b) 1% saline drinking water (9), (c) saline plus one injection of 250 mcg. hydrocortisone acetate following operation (8), (d) 250 mcg. DOCA per day (7), (e) 250 mcg. prednisone per day plus saline (13), (f) 250 mcg. hydrocortisone acetate per day plus saline (19), (g) 1 mg. hydrocortisone acetate per day plus saline (16), and (h) 250 mcg. DOCA plus 500 mcg. hydrocortisone acetate per day (12). Treatment groups (a) through (d) did not maintain lactation with mortality of pups on the 20th day of lactation being 100%, 78%, 92%, and 98%, respectively. Groups (e) through (h) maintained a level of lactation not significantly different from normal as judged by litter weights and mortality rates of pups. Milk production on the 14th day of lactation after 10 hours isolation of dam and pups was 8.9 gm. in normal group, 2.0 gm. in (a), 3.8 gm. in (b), 5.1 gm. in (d), 13.2 gm. in (g), and 9.7 gm. in (h).

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264. BLOOD HEMOGLOBIN LEVELS IN NEWBORN LAMBS. L. N. Baker*, *University of Massachusetts, Amherst.*

To determine the extent to which anemia may be a factor in the weakness and/or death of new born lambs and to evaluate the effects of injectable iron-dextran, 48 Shropshire and Dorset lambs were randomly alloted to three groups (1) control—no treatment (2) 300 mg. iron in an iron-dextran solution injected intramuscularly on day 1 and (3) 150 mg. iron on day 1 and again on day 7. All lambs were weighed and blood samples taken from the ear on day 1, 4, 7, 14 and 21. The rate of gain from day 1 to day 21 was not significantly influenced by

the treatments (0.48, 0.52, 0.56 lb.). Hemoglobin levels as determined by the acid hematin method were highest on day 1—14.3 gm. % for all lambs. The iron injections significantly aided in maintaining the hemoglobin levels in the treated groups—the average hemoglobin levels for the 21-day period were 11.4, 13.1 and 13.6 gm. %. The gross correlation coefficient of average daily gain and the average hemoglobin level for the first 21 days is 0.93. None of the lambs died during the experiment and none showed clinical signs of anemia.

265. EFFECT OF TRIS (HYDROXYMETHYL) ANINOMETHANE ON SPERMATOZOAN LIVABILITY. F. D. Bartlett, Jr.* and N. L. VanDemark, *University of Illinois, Urbana.*

Amine buffers have been used effectively for maintaining physiological pH. Tris (hydroxymethyl) aminomethane, Tris, has been useful in the treatment of acidosis and acts by direct titration of H^+ without immediate reduction in CO_2 content. Many times extra- and intracellular pH are widely different. The addition of Tris often produces equivalent extra- and intracellular pH changes which suggests ready intracellular penetration. Since the action of CO_2 in preserving spermatozoan life may involve intracellular pH change, it seemed advisable to test the use of Tris in the carbonated IVT diluent in which CO_2 concentration and pH are important factors. In a preliminary study, three concentrations of Tris (0.0125, 0.025, and 0.050M) were tested in two IVT diluents which differed in HCO_3^- concentration (0.025 and 0.050M). Extended semen was stored in glass ampules at 5, 15, and 26° C. At 26° C., the per cent of motile sperm at 0, 4, 7, 10, and 14 days was 60, 50, 37, 15, and 0% in the control diluent, and 60, 53, 50, 40 and 33% in the diluent containing 0.0125M Tris, respectively. At 5 and 15° C. the addition of Tris resulted in slightly poorer sperm survival. Tris was more beneficial in the diluent containing 0.050M HCO_3^- at 5 and 15° C., whereas, at 26° C. it was more beneficial in the diluent containing 0.025M HCO_3^-. At higher concentrations of Tris, poorer sperm survival resulted, although the differences were less at 26° C. than at 5 or 15° C. In general, the best survival was obtained at 15° C. Samples containing Tris maintained a higher pH and far greater dispersion of the egg yolk fat globules was apparent.

266. ATTEMPTS TO FLUSH MATURE EWES WITH A SODIUM PROPIONATE DRENCH AND PELLETED RATIONS. R. A. Bellows*, A. L. Pope, A. B. Chapman and L. E. Casida, *University of Wisconsin, Madison.*

Sixty-four mature white-faced ewes were divided into two groups and placed on pre-experimental conditioning rations for 51 to 117 days of either *ad lib.* hay (H) or *ad lib.* hay plus 2 lb. of grain (H+G) daily. They were then assigned to a factorially designed (2^3) feeding experiment of one estrual cycle duration. The factors studied as main effects and in interaction were: grain supplement vs. no grain supplement, sodium propionate drench vs. no sodium propionate drench, and pelleted rations vs. non-pelleted. All ewes were slaughtered in early estrus with ovarian follicular fluid weight being obtained as a measure of any flushing effect. Carcass weight, length and fatness score were also obtained. Statistical analyses of follicular fluid weights revealed: H vs. H+G, 0.40 vs. 0.48 gm. ($P<0.05$). Neither sodium propionate nor pelleting the ration gave significant increases in follicular fluid weight, 0.43 vs. 0.45 gm. and 0.41 vs. 0.47 gm., for control and treatment, respectively. Increases in carcass weight (45 vs. 60 lb., $P<0.01$) and carcass fatness score (2.0 vs. 6.4, $P<0.01$) were obtained for H vs. H+G, respectively. Pelleting increased carcass fatness score (3.6 vs. 4.8, $P<0.01$) over nonpelleted but not carcass weight, 50 vs. 54 lb., respectively. Correlations between follicular fluid weight and (1) carcass weight, (2) carcass length, and (3) fatness score were 0.40 ($P<0.01$), 0.26 ($P<0.10>0.05$) and 0.20 (N.S.), respectively. Decreased feed consumption was noted on the H+G pelleted ration.

267. TEMPERATURE EFFECTS ON HYDROCORTISONE 1,2-H^3 DEGRADATION RATES IN CATTLE. R. K. Bergman* and H. D. Johnson, *University of Missouri, Columbia.*

Extensive data were obtained during a 6 weeks trial on two lactating Holstein cows which were maintained in the Missouri Climatic Laboratory for 3 weeks at 65° F., 50% R.H. and then exposed to 88° F., 50% R.H. for 3 weeks. Each received weekly a 100 μ c injection of hydrocortisone 1,2-H^3 via the jugular vein. At 10-minute intervals after injection up to 2 hours post-injection, i.e. at 10, 20, . . . 110, 120 min. a 100 cc. sample of blood was taken from the jugular vein. The blood was heparinized, divided into duplicate samples, centrifuged, the plasma removed and frozen. Later each plasma sample was thawed and extracted with cold dichloromethane. The organic extract was washed with .1N NaOH and water and then evaporated to dryness. The dry residue was dissolved in scintillating fluid (toluene-PPO and POPOP) and the radioactivity measured in a Packard Tri-Carb Liquid Scintillation Spectrometer Model 314. Degradation slopes, (30–90 min.) of the tagged hormone were then plotted for each week of temperature exposure. The results indicate that the higher temperature does increase the hydrocortisone degradation rate during the first week, but that it reverts to near normal by the third week. For example the t ½ values for cow 12 are: 26 min., 22 min., 23 min., for the first, second, and third week at 65° F. and 17.5 min., 21 min., 23 min., at 88° F. The results indicate that the removal of tagged hydrocortisone from the blood stream may be influenced by a mechanism which recirculates the labeled hormone after its initial removal.

268. NEURAL AND BEHAVIORAL TASTE RESPONSES IN THE CALF. R. A. Bernard* and M. R. Kare, *Cornell University, Ithaca, New York.*

The taste responses of calves were studied combining electrophysiological recordings and preference tests. The chorda tympani nerve of young calves was exposed by removing the upper part of the mandible and dissecting the underlying muscles. Neural discharges resulting from chemical and tactile stimulation of the tongue were led through a series of electronic circuits that provided a permanent and quantifiable record of the total nerve response to each stimulus. Stimulus concentration-response magnitude functions were obtained for NaCl, HCl and

acetic acid starting at 0.001 M. KCl and propionic acid yielded responses starting at 0.01 M. Responses to fructose, glucose and xylose occurred at 0.5 and 1.0 M. Sodium saccharin and quinine sulphate gave weak responses at 0.003 and 0.001 M respectively. The calf is unusual in having chorda tympani responses arising from stimulation of both the posterior and anterior portions of the tongue. The chorda tympani is classically represented as innervating only the anterior two-thirds of the tongue. As in other species the glossopharyngeal nerve responded to tactile and chemical stimulation of the posterior tongue. No precise relationship between neural response and preference behavior was found. The sugars were more effective behaviorally than electrophysiologically. The wide range of response to acetic and propionic acids suggests a possible role for chemoreception in the mechanism of rumination.

269. RESPONSES OF SUMMER-CONDITIONED HEIFERS TO 90° F. J. Bond, J. R. Weldy, R. E. McDowell* and E. J. Warwick, Animal *Husbandry Research Division, ARS, U. S. Department of Agriculture, Beltsville, Maryland.*

This was the second study conducted to determine the effect of heat stress on reproductive and physiological responses of heifers. After summer grazing period three groups were placed on experiment at Beltsville, Maryland, September, 1960. Five were kept in a psychrometric chamber for 14 weeks at 90° F. and 60% humidity. The other groups were kept under prevailing ambient conditions with one group having artificial light similar to that of the heat chamber. All were fed a high-energy low-fiber ration according to weight. The groups housed under ambient conditions showed no significant changes in respiration rate or rectal temperature but water intake followed seasonal temperature while the chamber group showed significant changes in these measurements. Although rectal temperatures of the chamber group rose higher than similarly treated animals in the previous winter study only one animal ceased to cycle during the period. Respiration rates were not as high but were more variable than in the winter study. Water consumption showed a gradual increase through the period rather than a marked rise and decline as shown in the previous study. Indications are that a rise in rectal temperature had less effect on estrous cycle in summer-conditioned heifers. Hair coat depth of the chamber group increased slightly up to the fourth week (0.42 to 0.60 in.) then remained at this level for the next 10 weeks while that of the natural and artificial light groups increased at a rate normally expected. These findings further substantiate the important role of temperature in hair coat growth of cattle.

270. PROGESTINS IN BOVINE REPRODUCTIVE TISSUES AND BODY FLUIDS. A. M. Bowerman* and R. M. Melampy, *Iowa State University, Ames.*

Four corpora lutea were taken from each of three Hereford heifers, two at day 8 and two at day 16 of the estrous cycle. Aliquots were placed immediately in alcohol or incubated 2 hr. at 37° C. in Krebs Ringer bicarbonate glucose medium. Luteal tissue and placental tissues and fluids were obtained from pregnant animals at slaughter. Blood samples were obtained from the jugular vein. Mean endogenous progesterone concentrations of bovine luteal tissue increased from 29.2 mcg./gm. at day 8 to 47.2 mcg./gm. at day 16 of the estrous cycle. Δ^4 pregnan-20β-ol-3-one (20β-ol) increased from 0.3 mcg./gm. at day 8 to 2.0 mcg./gm. at day 16. Mean progesterone concentration increased 46.2 mcg./gm. in tissue from day 8 of the cycle and 53.4 mcg./gm. in tissue from day 16 during 2 hr. incubation in Krebs Ringer bicarbonate medium. Increases of 20β-ol concentration on incubation were 2.1 and 12.4 mcg./gm. at day 8 and 16, respectively. Mean concentration of progesterone ranged from 4.0 to 18.2 mcg./gm. and 20β-ol from 3.3 to 10.5 mcg./gm. in luteal tissue at seven stages of pregnancy investigated. Neither progesterone nor 20β-ol was detected in placental fluids and only progesterone (4.4 mcg./kg.) was found in one of six placentae. Blood plasma from pregnant animals contained 0 to 2.13 mcg. progesterone/100 ml. plasma and no detectable 20β-ol.

271. EFFECT OF POTASSIUM ON RUMEN FUNCTION. M. F. Brink* and W. H. Pfander, *University of Missouri, Columbia.*

Twenty-eight lambs were employed in a digestion trial to study the effect of dietary potassium levels of 0.2, 0.3, 0.5 and 0.9% on *in vivo* cellulose digestion. The 0.2, 0.5 and 0.9% levels were about equal with regard to *in vivo* and *in vitro* cellulose digestion. On the other hand, 0.3% depressed digestion. Cellulose digestion on 0.5% potassium was comparable with other levels even though feed intake was greater. *In vivo* volatile fatty acid concentration and *in vitro* production were determined at 0, 1, 1½, 2, and 2½ hours after feeding on one lamb from each dietary potassium level. The 0.3% level produced a significantly greater amount of *in vivo* total acid than other levels of potassium. *In vitro* production was greatest on 0.3% potassium. Partitioning data revealed that acetic acid predominated on all levels, however, it was considerably higher on the 0.5% level. Propionic acid was next highest in concentration on the 0.3 and 0.5% levels followed by valeric acid. However, butyric acid was of second highest concentration on the 0.2 and 0.9% levels followed by isovaleric acid. 0.5% potassium appeared to be optimum for normal rumen function.

272. STUDIES ON THE FORMATION OF CORPORA LUTEA IN GILTS, H. J. Brinkley* and A. V. Nalhandov, *University of Illinois, Urbana.*

The time of release of LH and/or LTH was studied in 48 sexually mature gilts. They were fed Provera (Upjohn) for 9 days which caused a near-complete destruction of all follicles. Provera was withdrawn and, at the end of a recovery period of 6 days, ovaries of all animals contained follicles of ovulable sizes. Half of the gilts were injected daily with 400 mg. of progesterone (P) in oil from day 7, until autopsy. They were also injected intravenously on days 7, 8, or 9 with LH (HCG). The remaining half of the animals was not injected with P but was given LH on the same days as the other group. Both groups were killed 10 days after the single LH injection. P blocks the pituitary gland about 48 hours after the first injection and the

majority of the follicles become inovulable. All animals given LH prior to that time, ovulated and formed corpora lutea (CL). At autopsy the ovaries and CL of both groups, with or without progesterone blockade, were identical. Results support the idea that normally a release of hypophyseal LH lasts less than 48 hours; more prolonged release is unnecessary for the production of normal CL. If an LTH is produced it too is secreted over a short period and subsequent release of LTH seems unnecessary for the maintenance of CL for at least 10 days after ovulation.

273. ROLE OF THE THYROID GLAND IN THE FERTILITY OF RAMS. Jerry R. Brooks* and C. V. Ross, *University of Missouri, Columbia.*

A three-year study was made of the influence of the thyroid gland upon apparent fertility of mature rams. Semen quality was studied in Hampshire rams subjected to: (1) thyroxine therapy under two levels of ambient temperature, (2) goitrogenic immobilization of the thyroid, and (3) thyroidectomy. In four trials using an average of 13 rams, it was observed that at approximately 80° F. a critical temperature point was reached and semen quality declined. About 4 weeks at 70° F. were required for semen quality to return to normal. However, after exposure to 92° F. ambient temperatures for three days approximately eight weeks were required for rams to recover apparent fertility. Although daily injected L-thyroxine levels of 0.2, 0.3, or 0.4 mg. per 100 lb. body weight had no significant effect on semen quality, thyroxine treated rams under higher environmental temperatures produced semen consistently lower in quality than that from untreated rams under similar conditions. Thyroxine appeared to accentuate the effect of heat on semen quality. Daily doses of 800 mg. of the goitrogen, tapazole, per 100 lb. body weight induced severe hypothyroidism in rams but had no detrimental effect on their apparent fertility. Mortality rate was high among those receiving the drug. Four rams were thyroidectomized and semen samples collected for five weeks following the operation. There was apparently no effect mediated by thyroidectomy on either semen quality or libido.

274. FREE AMINO ACIDS OF BOVINE PLASMA —IDENTIFICATION AND EFFECT OF FASTING. Harold E. Brown*, H. O. Kunkel and J. M. Prescott, *A. & M. College of Texas, College Station.*

Blood samples were taken from six yearling beef heifers of Hereford breeding to identify and determine the effect of fasting on the free amino acids of bovine plasma. The animals were fasted for a period of 88 hours with samples being taken at 24-hour intervals following a 16-hour equilibration period after the last feeding. Analyses for ninhydrin reactive substances were made with chromatographic techniques and the following compounds were identified; lysine, tryptophan, histidine, phenylalanine, tyrosine, leucine, isoleucine, threonine, methionine, valine, glycine, alanine, serine, cystine, aspartic acid, glutamic acid, proline, citrulline, ornithine, arginine, urea, and ammonia. No hydroxyproline was detected. Four other ninhydrin reactive substances were separated but have not yet been identified. One of these compounds may be a keto-acid. Several characteristic changes in the relative concentration of free amino acids in plasma accompanied extended fasting. The glycine level was increased early in the fast approximately twofold. Other compounds showing a significant gradual increase with fasting were the aromatic amino acids, ammonia, citrulline, ornithine, lysine, valine, threonine, leucine and isoleucine. Serine and alanine decreased in concentration. Changes in concentration of glutamic acid, cystine, histidine, and arginine were only slight.

275. RELATION OF UTERUS TO ESTROUS CYCLE IN GUINEA PIGS. R. L. Butcher* and K. Y. Chu, *Iowa State University, Ames.*

Fifty-six virgin sexually mature guinea pigs (seven groups of eight each) were hysterectomized on the fifth or sixth day of the estrous cycle. Group I had the uterus removed from tubo-uterine junctions to os uteri. Groups II through VII (subtotal hysterectomy) had the following portions remaining: cervix; uterus posterior to the external bifurcation; uterus posterior to the external bifurcation plus posterior one-fourth of one horn; one horn; anterior one-half of one horn; and anterior one-fourth of one horn, respectively. Animals were sacrificed following the third estrus or 130 days after the preoperative estrus if a third estrus had not occurred. The mean length of the first estrous cycle following the preoperative estrus and number of animals (from groups of eight) showing estrus before 130 days in Groups I through VII were: 83, 6; 87, 4; 45, 8; 39, 8; 27, 8; 32, 7; and 64, 7, respectively. Sham operations had no effect on estrous cycle length. These data indicate a direct relationship between the quantity of organ remaining after hysterectomy and length of the first postoperative cycle. There did not appear to be any relationship between the location of the remaining uterine portion and subsequent cycle lengths. Luteal and follicular development following total hysterectomy was similar to that found at mid-gestation. Cycles were observed in females following autotransplants of the complete uterus.

276. HORMONE INDUCED WEIGHT GAINS IN ADULT FEMALE MINK. Robert L. Cochrane* and James R. Leekley, *U. S. Dept. of Agri. and Alaska Exp. Station, Petersburg.*

Sixteen adult female mink that failed to whelp or raise their young during the previous breeding season were paired as to initial body weight, age and reproductive performance and were allotted, one each, to a treated and control group. Each treated animal received a subcutaneous injection of 2.4 mg. of progesterone and 24 μg. of estradiol benzoate in 0.25 cc. of corn oil daily from July 23rd through August 12th, while the controls received 0.25 cc. of corn oil daily over the same period. All animals were supplied feed and water *ad libitum*. The ration consisted of 50% chum salmon waste, 20% flounders, 16% mink cereal, 2% wheat germ meal and 12% added water. Body weights were taken to the nearest 0.05 lb. at the beginning and end of the experimental period. The treated females gained an average of 0.47 lb., increasing from an average body weight of 1.64 to 2.11 lb., while the controls lost 0.08 lb., decreasing from an average body weight of 1.68 to 1.59 lb. This difference in weight gain of the two groups was highly significant ($P<.01$).

277. INHIBITION OF ENDOGENOUS GONADOTROPINS BY ANTIGONADOTROPINS. H. H. Cole and R. B. Snook*, *University of California, Davis.*

The antigonadotropins employed in this study were obtained from mares stimulated to produce antibodies to HCG and crude sheep FSH, by subcutaneous injections in conjunction with Freund's adjuvant (Difco). A combination of 1 ml. of anti-HCG (100 times the amount needed to completely inhibit 20 IU of HCG in the rat) and 2 ml. of anti-FSH (twice the amount needed to inhibit an amount of FSH producing 50 mg. ovaries in the rat) injected twice weekly for 4 weeks inhibited the endogenous gonadotropins in the immature rat. This combination resulted in ovaries weighing 19.6 mg. as compared to 41.3 mg. in uninjected controls at 54 days. The injection of 1 ml. of anti-HCG twice weekly alone resulted in ovaries weighing 51.0 mg. and the injection of 2 ml. of anti-FSH twice weekly alone resulted in ovaries weighing 45.0 mg. Thus, there is evidence that the two antisera synergize in inhibiting the response to endogenous gonadotropins. Studies on the withdrawal effect of antigonadotropins on endogenous gonadotropins showed that the antigonadotropins had no lingering action. In five rats injected daily with 1 ml. of anti-FSH plus 1 ml. of anti-HCG from the 27th to 38th days, one rat manifested an estrous smear on the 43rd and the other four on the 44th day of age. Thus it appears that antihormones may be useful in synchronizing estrus. These rats were sacrificed 16 days after cessation of treatment; the ovaries and uterus were within the weight range of untreated controls.

278. EFFECT OF AGE ON FERTILITY OF BULLS. W. E. Collins*, E. K. Inskeep, W. H. Dreher, W. J. Tyler and L. E. Casida, *University of Wisconsin, Madison and Badger Breeders Cooperative, Shawano, Wisconsin.*

The effect of age on fertility of Holstein and Guernsey bulls used for 1000 or more services per year was examined in the 60- 90-day non-return records of Badger Breeders Cooperative from 1947 through 1959. The terminal year of services was excluded if the bull was culled either because of low fertility or poor semen quality. This exclusion eliminated records on bulls whose fertility dropped markedly in a short period of time. A total of 96 Holstein and 84 Guernsey bulls served in the stud during these 13 years. Ninety-one Holsteins and 66 Guernseys had one or more records which met the criteria established for inclusion in the analysis. The two groups contributed 322 and 218 bull-years, respectively. In each year, the deviation of the non-return rate of each bull from the stud average for his breed was calculated. These deviations, which were intended to minimize the effect of year, were analyzed for differences among age groups by a separate analysis of variance for each breed. Differences among age groups were highly significant ($P<0.01$) in both breeds. Regression analysis showed a highly signifiacnt decline in non-return rate of 0.31 and 0.50% per year of age for Holsteins and Guernseys, respectively. Deviations from linear regression were non-significant although there was a trend toward a sharper decline beginning at 6 or 7 years of age. The age effect in the later age groups is actually underestimated because the culling rate for fertility reasons was greater in these groups.

279. SYNCHRONIZATION OF ESTRUS AND LAMBING IN EWES FED 6-METHYL-17-ACETOXYPROGESTERONE. Weslie Combs*, M. P. Botkin, and G. E. Nelms, *University of Wyoming, Laramie.*

Eighty-one Rambouillet and Columbia ewes were fed 6-methyl-17-acetoxyprogesterone (Provera, The Upjohn Co.) in groups of 12, 29, and 40. Estrus was synchronized by feeding 120 mg. per ewe per day in ½ lb. ground grain once daily for 13 days. Ewes began coming into heat about 48 hours after the last feeding. Of the 81 ewes, 75 were marked on the third, fourth and fifth days post-feeding. In the group of 29, four ewes were marked on the sixth day post feeding and two remained unmarked. Extreme cold and snow made detection of marks in this group difficult. Ewes were pen mated in groups of 12, 29, and four groups of 10 each with a single ram per pen. First service conception rates were 11/12, 13/29, 9/10, 7/10, 4/10, and 3/10 with an average rate of 58%. The lowest conception rates were in the largest breeding group and in the two groups served by previously untried yearling rams. Ewes not conceiving on first service remained synchronized and all conceived on second service except five from the group of 29 which did not lamb. Lambings were concentrated in 7–8 day periods separated by a 7–10 day period during which only a few ewes lambed. Lamb numbers were normal and were equal to controlled comparisons. Conception rates appeared to depend upon the capacity of the ram.

280. FEED LEVEL, ALFALFA AND FERTILITY IN YOUNG COWS. V. Cruz*, A. C. Warnick, T. J. Cunha and M. Koger, *University of Florida, Gainesville.*

Twenty-four 3-year-old Brahman x Angus crossbred heifers, pregnant for more than 6 months, were randomly assigned to one of three rations. Group I was fed corn, citrus pulp, cottonseed meal, minerals and vitamins with protein and TDN as recommended by N.R.C.; Group II was 20% higher in TDN and protein; and Group III had same TDN and protein as Group II but included 6 lb. dehydrated alfalfa pellets. Each heifer was fed for 120 days after calving and was bred at the first postpartum estrus. Group I heifers consumed approximately 94 and 99% of the N.R.C. TDN and protein requirements, respectively, during lactation and lost 25 lb.; only three heifers showed estrus with two becoming pregnant; the interval from parturition to estrus was significantly longer ($P<0.05$) than the other groups. Group II heifers consumed at least 20% more TDN and protein than Group I during lactation period; five heifers came into estrus, 11 days earlier than in Group I and all that came into estrus became pregnant. The highest weight gains of 59 lb. during lactation were made by the alfalfa fed heifers in Group III; they had the highest reproduction performance with the shortest interval to first estrus; seven showing estrus with six becoming pregnant. The recommended N.R.C. levels for either TDN and/or protein were inadequate for reproduction with these 800-lb. crossbred heifers during their first lactation. This is the second of three trials in which dehydrated alfalfa has improved reproduction performance of heifers.

281. REPRODUCTIVE PERFORMANCE IN GILTS ADMINISTERED FOLLICLE STIMULATING HORMONE. B. N. Day*, F. E. Romack, and J. F. Lasley, *University of Missouri, Columbia.*

The influence of exogenous follicle stimulating hormone (FSH) on ovulation rate and subsequent litter size in Poland China gilts was determined. A trend toward increased ovulation rate was observed in the gilts administered FSH but no improvement in litter size was apparent. The following experimental groups were studied: (I) thirty-one gilts were designated as control animals (II) twelve gilts were injected intramuscularly with 15 Armour Units of FSH per animal, and (III) fourteen gilts were injected intravenously at a dose level of 30 Armour Units of FSH per animal. All gilts were checked twice daily to determine the onset of estrus. A single injection of the hormone preparation was made immediately following the detection of estrus. All gilts were bred on the first day of estrus and a second mating was made 12 to 24 hours later when possible. The gilts were slaughtered on approximately the 25th day of gestation to determine the number of corpora lutea and litter size. Sixty-five percent of the control gilts were pregnant when slaughtered. The average conception rate for the two groups of injected gilts was 85%. Average ovulation rate and number of living embryos per litter for groups I, II, and III were 10.2, 8.3; 11.8, 8.4, and 11.2, 8.5, respectively.

282. CONTROL AND SYNCHRONIZATION OF OVULATION IN SWINE. P. J. Dziuk and R. D. Baker*, *University of Illinois, Urbana.*

Oral administration of 500 mg. of 6α methyl 17α hydroxyprogesterone acetate (Provera-Upjohn) per female once a day for 9 days completely inhibited follicle growth in gilts. Withdrawal of treatment caused normal follicle growth. Spontaneous ovulation did not occur before 10 days after the end of treatment and 18 days after treatment 42% had ovulated. No large cystic follicles were formed and follicles appeared to be normal 8 to 10 mm. preovulatory follicles from day 6 to 10 after the end of treatment. Intravenous injection of 4 cc. of HCG solution (250 to 2000 iu) on days 5, 6, 7, or 8 after treatment caused ovulation in 96% (94 of 98) animals examined 40 or more hours after HCG. The 4 females not ovulating began treatment on days 18, 19 or 20 of the estrous cycle. Subsequently treatment was not started on animals with a swollen vulva. HCG given subcutaneously (1000 iu) or intramuscularly (750 iu) caused ovulation in 10 of 10 animals. Ovulation rarely occurred before 36 hours, began about 39 hours, was 70 to 90% complete at 40 hours and was complete at 42 hours, after HCG. There were 15.3 ovulation points per ♀ ovulating. Seventeen of 30 (56%) of ovulating females artificially inseminated 24 hours after HCG had fertilized ova 48 hours later and 3 of 18 (17%) similarly treated females had fetuses 25 days later. Only 2 of 253 treated animals showed heat at ovulation.

283. BREEDING PERFORMANCE IN EWES FOLLOWING SYNCHRONIZATION OF ESTRUS BY FEEDING PROVERA. J. S. Evans*, E. C. Simpson and R. H. Dutt, *University of Kentucky, Lexington.*

In November 1959, 35 dark-faced, cross-bred northwestern ewes were fed 50 mg. of Provera (6-methyl 17-acetoxyprogesterone) in a grain ration once daily for 14 days. Ewes were started on treatment at all stages of the cycle, and none came into estrus during treatment. Twenty-nine (82.9%) returned to estrus 2 to 8 days (av. 3.14) after Provera feeding was stopped. Ewes showing estrus were artificially bred, and 10 were slaughtered 3 days later for fertility data. Ovulation rate was 1.2 and 70% of the ova were cleaved. Nine of the remaining ewes returned to estrus (av. 16.4 days) after breeding. Eight (42.1%) of the bred ewes lambed. In November 1960, a similar trial was conducted with 40 ewes. A factorial design was used in which 60 or 90 mg. of Provera was fed daily for either 15 or 18 days. None of the ewes came into estrus during treatment. Thirty-eight (95.0%) of the ewes returned to estrus 2 to 5 days (av. 3.2 days) after Provera feeding ended. Variance in time of onset of estrus was reduced from 18.2 to 2.8 in the first trial and from 18.3 to 0.6 in the second trial for pre-treatment and post-treatment estrus, respectively. Average interval from end of feeding to onset of estrus was significantly longer for the 90-mg. group (2.7 days vs. 3.6 days, $P<.01$) and for the 18-day group (2.9 days v. 3.6 days, $P<.01$). Ewes showing estrus were artificially bred and 19 were slaughtered. Ovulation rate was 1.4 and 63% of the ova were cleaved. Sixteen of the remaining 19 ewes (84.2%) lambed to the first post-treatment breeding.

284. "IMMUNITY-GAP" STUDIES ON BABY PIGS. Russell A. Eversole*, Philip W. Peterson, and Francis C. Wingert, *Cargill-Nutrena Research Laboratories and Research Farm, Elk River, Minnesota.*

Attempts to define time course, peak titers, rates of antibody decay, and periods of susceptibility of baby pigs in relation to an "immunity-gap" have revealed a spectrum of different immune responses in the pigs. In two series of experiments, where titers of the piglets blood and the sow's milk and blood were measured at regular time intervals from before farrowing of the sows and before nursing of the pigs up to pigs at 27 weeks of age, the time course of piglet titre level was either: (a) negligible throughout the first few weeks, (b) reached a high level in 7 days, although frequently not in 24 hours, and then decayed thereafter with a half-life of 4 ± 1 days, or (c) reached a high level as in (b) above but did not decay, persisting at the high level for considerable time periods. The killed bacterial antigen used to detect response (a) above was the non-endogenous bacterium, *Serratia marcesens;* for (b) above, they were various endogenous antigens isolated from the farrowing areas just prior to these experiments, namely, *Staphylococci, Proteus,* and coliform isolates; for (c) above they were *Erysipelothrix rhusiopathiae,* which had been previously used in the same swine herd as a live avirulent vaccine, and *Serratia marcesens* only in those pigs which were injected intramuscularly with a killed bacterin of the same strain at five days of age. It is concluded that: (1) the susceptibility period of the "immunity-gap" probably occurs in the neighborhood of between 3 and 20 weeks of age, and (2) isolated farrowing units are of definite advantage.

285. PHYSIOLOGICAL ABERRATIONS IN SYNDACTYLOUS CATTLE. Earl L. Farmer* and Keith Huston, *Kansas State University, Manhattan.*

A female herd manifesting the syndactylous factor has been maintained for genetic investigations for more than eight years. During this period several animals have either died or had to be destroyed due to an apparent inability to withstand the rigors of ambient temperatures above 90° F., parturition or lactation. Although the animals affected by any of the aforementioned conditions either were initially unable or refused to stand, all other physiological observations such as pulse rate, body temperature, respiratory rate, and differential blood counts were within the normal range until secondary infection was evident. The apparent low tolerance of these animals for stress and the observation of a possible abnormal water intake suggested either an adrenal or hypophyseal insufficiency. Trials were conducted to test the hypothesis of adrenal insufficiency. These trials were primarily triple reversal trials involving four syndactylous and four normal animals all of similar age. The observations included response to exogenous ACTH, plasma sodium, potassium and glucose assays, pulse and respiratory rates, and body temperature. Total water intake and urine excretion was measured for seventy-two hours to document the possibility of abnormal water intake and excretion as urine. Data tabulated to date are inconclusive with respect to the hypothesis of adrenal insufficiency. The only recovery of a syndactylous animal, showing the effects of low tolerance for stress, was as a result of maintenance of ambient temperature at 85° F., administration of cortisone and antibiotics, and drenching daily with 160 gm. of sodium propionate.

286. FACTORS AFFECTING OVULATION AND FOLLICULAR CYST FORMATION IN SOWS AND GILTS FED 6-METHYL-17-ACETOXYPROGESTRONE. N. L. First*, F. W. Stratman, E. M. Rigor and L. E. Casida, *University of Wisconsin, Madison.*

Some of the major factors affecting follicular cyst development following the oral administration of 6-methyl-17-acetoxyprogesterone were studied. Eighty of 141 sows and gilts had one or more cystic follicles (>14 mm.) when autopsied 3 days after the beginning of estrus. The cystic follicles were induced in sows or gilts of 5 breeds. Hormone doses less than 50 mg. per head per day did not prevent estrus during treatment. A daily dose of 50 through 75 mg. prevented estrus in most gilts and doses above 100 mg. completely prevented estrus during treatment. Forty-eight gilts were individually fed 75 or 150 mg. of hormone per day starting either 8, 13 or 18 days after the first day of the previous estrus. For day 8 or 13 more gilts receiving 150 mg. per day ovulated and developed corpora lutea than gilts receiving 75 mg. Of the gilts receiving 75 mg. follicles ovulated and fewer became cystic if they began hormone treatment during the follicular phase of the cycle (day 18) than during the luteal phase (day 8 or 13). There was a significant interaction between the effects of day of cycle and hormone dose on number of follicles ovulating. ($P<.01$). Thirty-six sows were individually fed 30, 60 or 240 mg. per head per day for 10 or 20 days starting day 16 of the estrous cycle. Rectal palpation before treatment, the last day of treatment and autopsy 3 days after estrus revealed that follicular cysts occurred during treatment when the daily dose was 60 mg. and after hormone withdrawal when a 240 mg. daily dose was fed.

287. SOME CARRY-OVER EFFECTS OF PROGESTRONE AND ESTRADIOL TREATMENTS ON REPRODUCTIVE PHENOMENA IN THE EWE. W. C. Foote* and Albert B. Waite, *Utah State University, Logan.*

Thirty-nine whiteface ewes were divided into four groups and treated as follows: (1) received seventeen daily intramuscular injections of 10 mg. progesterone in oil; (2) same as group one plus a single intramuscular injection of 15 mg. estradiol in oil 12 hours after the last progesterone injection; (3) received a single injection of estradiol only at the same time as group two and (4) a control group receiving no injections. Injections were begun regardless of stage of cycle. Laparotomies and autopsies were performed to determine post-treatment ovarian changes. Range and average in days to estrus for the four groups respectively from time of last progesterone injection (one-half day less for estradiol) were 2.25–3.25, 2.8; 100–3.50, 1.6; 1.00–28.50, 7.0 (one ewe failed to return to heat); 1.00–16.50, 10.6. Ewes receiving estradiol in addition to progesterone demonstrated estrus significantly earlier than those receiving progesterone only and both were significantly earlier than the remaining groups. Estrus was not always accompanied by ovulation in groups receiving estradiol. Estrous period lengths were not affected by any of the treatments, but cycle lengths were greatly shortened or lengthened in estradiol groups; cystic follicles were not responsible. Progesterone did not affect ovulation rate. There was no treatment effect on number of vesicular follicles or ova fertilized. Ewes receiving progesterone only remained synchronized for the duration of the study (three estrous periods). A low incidence of maintenance of corpora lutea marked with silk thread was noted in control and estradiol groups. Data indicate that for level of hormone used major actions of both were mediated through the adenohypophysis with progesterone inhibiting and estradiol facilitating release of LH.

288. FREEZING BULL SEMEN IN LIQUID NITROGEN VAPOR WITHOUT INSTRUMENTATION. J. L. Forgason*, W. T. Berry, Jr., and D. E. Goodwin, *Winrock Farms, Morrilton, Arkansas.*

Semen from two Santa Gertrudis bulls (372 ampules) was frozen by two methods to measure freezing rates and efficacy of each. Semen frozen with carbon dioxide in an alcohol bath was compared with semen frozen in liquid nitrogen vapor. The rate of freezing in alcohol bath was regulated by a cam controlled electrical valve which maintained a temperature drop from +5° C. to −15° C. at a rate of 3° C. per minute and from −15° C. to −50° C. at a rate of 5° C. per minute. There was no control of freezing rate of semen in the liquid nitrogen vapor as the ampules were placed directly into the refrigerator. Freezing rates within ampules in liquid nitrogen vapor were determined by thermocouple technique to be 2.5° C. per minute from +5° C. to −15° C. and 6° C. per minute from −15° C. to −50° C. Freezing rates within liquid

nitrogen vapor were only slightly affected by location or insulating materials, and the average survival rate for this method of freezing was 65.7%. Carbon dioxide with alcohol bath gave a survival rate of 68.3% which was not statistically different from that of the liquid nitrogen method. Semen can be successfully frozen by transferring ampules of extended semen from a ∓5° C. work room directly into a liquid nitrogen vapor refrigerator without any instrumentation to control freezing rates.

289. UREA AND NITRATE ION CLEARANCE IN SHEEP. G. B. Garner*, R. A. Bloomfield, J. Hersey, E. O. Kearley and M. E. Muhrer, *University of Missouri, Columbia.*

Field observations indicate that urea fed animals are more susceptible to nitrate toxicity than non-urea fed animals on comparable rations. This study was conducted to evaluate the rate of clearance for nitrate and urea in the blood. Four wethers and two heifers were intravenously given sodium nitrate alone, urea alone and in combination. Hourly blood samples were taken for nitrate and urea analysis. Urine was collected whenever possible from the wethers and the heifers were catheterized. Nitrate determinations were made on the urine. From the data gathered the urea space was calculated to be 67–78% of the body weight for sheep and 51–59% for the heifers. The calculated nitrate space was 23–36% of body wt. for sheep and 20–33% for the heifers. Thus it appears from these data that nitrate is in equilibrium with extra cellular fluids of ruminants. The nitrate was cleared from the blood at an average rate of 0.27 mM/L/hr. while urea was cleared at a rate of 1.7 mM/L/hr. in the sheep. The blood clearance rate for the heifers were 0.21 mM/L/hr.; 1.3 mM/L/hr. nitrate and urea, respectively. When nitrate and urea were injected simultaneously the rate of clearance of nitrate appeared to be diminished from these limited observation. The average nitrate recovery in the urine was 16% and 27% of the dose for sheep and heifers, respectively.

290. EFFECT OF LEVEL OF DIETARY ENERGY ON SOME REPRODUCTIVE PHENOMENA OF GILTS. L. Goode*, A. C. Warnick and H. D. Wallace, *University of Florida, Gainesville.*

The effect of restricting energy intake on some reproductive phenomena was studied in three experiments utilizing a total of 96 Duroc gilts. A high energy diet containing 10% alfalfa leaf meal and a low energy diet containing 52% alfalfa leaf meal were fed in all experiments. In the third experiment a second low energy diet containing 10% alfalfa leaf meal was included. The experimental diets were designated High Energy, Low Energy I and Low Energy 2 respectively. The adjusted diet means for age (days) and weight (lbs.) at puberty, ovulation rate and number of viable embryos at 25 days of gestation were as follows: (1) High Energy—268, 333, 14.9, 11.7; (2) Low Energy 1—296, 287, 15.3, 13.2; (3) Low Energy 2—307, 321, 14.5, 11.9. Restricting energy intake reduced weight at puberty and delayed the onset of puberty ($P<0.05$). Differences in ovulation rate between diets were not significant but favored the Low Energy 1 died, containing 52% alfalfa leaf meal, in all experiments. Gilts on the Low Energy 1 diet showed the highest embryonic survival rate and contained more viable embryos ($P<0.06$) than those on the High Energy diet. At 25 days of gestation the average units of alkaline and acid phosphatase activity in the endometrium were 0.560 and 3.41 respectively. Differences in enzyme activities between diets were not significant. Alkaline phosphatase activity was negatively correlated, $r=-0.351$, ($P<0.05$) with number of viable embryos.

291. ANTIBIOTIC INFLUENCE ON REPRODUCTION IN GILTS. R. C. Gray, Jr. and C. D. Squiers*, *Auburn University Agricultural Experiment Station, Auburn, Alabama.*

Sixty-four gilts, raised on concrete, were lotted at 112 days of age. Treatments were: (1) high-energy ration on concrete to 200 lb., high-level terramycin at breeding, (2) high-energy ration on concrete to 200 lb., no antibiotic at breeding, (3) low-energy ration to 200 lb., high-level terramycin at breeding, and (4) low-energy ration to 200 lb., no antibiotic at breeding. After reaching 200 lb., all gilts received low-energy ration on pasture until 5 days (mean) before breeding. At this time all gilts were placed on high-energy ration. Gilts on treatments 1 and 3 received 0.6 gm. (mean) terramycin orally for an average of 5 days before and after breeding. All gilts were bred on second estrus after 7 months of age, on two successive days, and to at least two boars. Thirty days after mating, all gilts were slaughtered and counts made of the number of corpora lutea and embryos. Neither treatment had a statistically significant influence on ovulation rate, number of embryos, or embryonic death.

292. HORMONAL CONTROL OF MAMMARY GLAND INVOLUTION IN THE RAT. David R. Griffith* and C. W. Turner, *University of Missouri, Columbia.*

Previous studies in this laboratory have employed desoxyribonucleic acid (DNA) as a quantitative index of the mammary gland growth cycle during pregnancy, lactation, and involution. The present study was carried out to investigate the effects of oxytocin (O), hydrocortisone acetate (HC), and lactogenic hormone (L) upon mammary involution. Young were separated from control and experimental animals on day 3 of lactation and mammary gland DNA was determined 10 days after weaning. This time period was required for mammary gland DNA to revert to virgin control values in the non-treated group. Experimental animals received 2 IU of O 3 x daily, 1 and 2 mg. L, and 100, 500, and 1000 mcg. of HC daily from the day of weaning. O did not prevent the retrogression of mammary gland DNA at day 10 of involution. L (1 and 2 mg.) greatly retarded involution; however, mammary gland DNA was not maintained at the lactational level. HC at the 100 mcg. level did not prevent involution but both 500 and 1000 mcg. prevented involution approximately equal to that observed with L. L and HC also appeared to maintain active milk synthesis. Direct evidence that O will not cause release of lactogen from the pituitary of nembutolizid lactating rats presented previously indicates lack of physiological effect of O on lactogen release or on mammary gland. Since L retarded involution but O did not, the hypothesis that O indirectly prevents involution

by causing the release of L was not supported by present data.

293. WATER AND ION CONCENTRATIONS IN THE SHEEP UTERUS. H. W. Hawk*, G. D. Turner and T. H. Brinsfield, *Animal Husbandry Research Division, ARS, Agricultural Research Center, Beltsville, Maryland.*

Determinations were made on uterine endometrium and myometrium of ten estrous (E), seven luteal-phase (L) and five ovariectomized (O) ewes. In both E and L ewes the endometrial water content was higher than in O ewes ($P<0.01$ for each comparison). The E and L ewe group had greater proportions of water in the extracellular phase (Na space) and higher Na and Cl concentrations. Mean water concentrations for E, L and O ewes, respectively, were 86.1%, 86.0% and 82.4%; percent of total water in the extracellular phase: 58.7, 57.0 and 52.1; total Na (mM/Kg wet tissue): 89.0, 86.3 and 78.4; intracellular Na: 15.9, 15.5 and 15.4; Cl (mM/Kg): 75.9, 71.2 and 66.0; K (mM/Kg): 49.1, 42.6 and 50.0. In the myometrium, E and L ewes again had a higher water content than did O ewes ($P<0.01$ for each comparison). Extracellular water volume and Na content per unit weight of wet tissue were progressively greater in E, L and O ewes, and intracellular water volume and K content progressively less. Mean myometrial water contents for E, L and O ewes were 83.2%, 82.4% and 80.3%; percent extracellular water: 45.8, 48.8 and 52.1; total Na: 70.1, 72.6 and 76.1; intracellular Na: 15.0, 14.4 and 15.0; Cl: 62.0, 61.3 and 64.8; K: 59.0, 53.0 and 49.1. Endocrine state had different effects in endometrial and myometrial tissue on water distribution and some ion concentrations. Increasing age (varying from 2 to 10 years) was associated with a decrease in endometrial water content in the E group ($r=-.667$, $P<0.05$), but not in the L or O groups.

294. THE SYNCHRONIZATION OF ESTRUS IN SHEEP. F. C. Hinds*, P. J. Dziuk, J. M. Lewis, *University of Illinois, Dixon Springs Experiment Station, Robbs.*

The control of estrus in sheep could prove to be a useful tool to the sheep industry. The experimental animals were 88 grade ewes of varying sizes and origins, randomly assigned to four groups of 22, with age and origin equalized within each group. In an attempt to inhibit estrus in cycling ewes, two levels (0.75 and 100 mg.) of 6 alpha methyl 17 alpha hydroxy progesterone acetate (U-8839, or Provera, Upjohn Company) were fed in a half-pound of grain to each animal daily for 14 days. Two groups of 22 ewes received no U-8839 whereas the other two groups were offered, individually, one of the two levels of U-8839. The actual consumption of the U-8839 was 58 and 75 mg. per head per day. Raddle-mark data during the U-8839 feeding period indicated a cessation of estrus in the treated ewes consistently consuming their ration. Ewes not receiving U-8839 continued cycling during this period. During the 5 days following the U-8839 feeding period, 86% of the treated ewes were considered served as compared to 38% of the control ewes. Sixty-three and 84% of the treated ewes (75 and 100 mg.) lambed during the expected period of time as compared to 35 and 26% of the control ewes. There was no difference between controls and treated with respect to sex ratio, birth weight, percent of ewes lambing or numbr of lambs per ewe. Yearling ewes did not respond as consistently as aged ewes.

295. FERTILITY OF EWES BRED NATURALLY AND ARTIFICIALLY AFTER ESTROUS CYCLES SYNCHRONIZED WITH AN ORAL PROGESTATIONAL AGENT. D. E. Hogue*, Wm. Hansel and R. W. Bratton, *Cornell University, Ithaca, New York.*

One hundred and twenty mature western whiteface ewes were randomly assigned to three groups of 40 each and treated as follows: (1) a control group, which was allowed to cycle normally and bred naturally; (2) an experimental group which was allowed to cycle normally and inseminated artificially intra-cervically on two successive days with 0.5 ml. of fresh semen diluted with physiological saline; (3) an experimental group in which estrus was synchronized by feeding 60 mg. of 6-methyl-17-acetoxy-progesterone per ewe per day for 20 days. Half of this group was bred naturally and half artificially. Of the 40 ewes fed the oral progestational agent, 37 (92½%) were observed to be in estrus from 50–64 hours after the last feeding. The conception rates, from breeding at one cycle only, indicated by lambing records were as follows: naturally bred at normal estrus, 50%; artificially bred at normal estrus, 49%; naturally bred at synchronized estrus, 61%; artificially bred at synchronized estrus, 16%. All of the synchronized ewes not conceiving at this estrus returned to estrus on either day 15 or 16 and were still essentially "synchronized." On the basis of the percent 30-day non-returns to estrus the range in fertility of the individual rams used was from 26% to 75%.

296. MATING BEHAVIOR IN SHEEP. PART I. MATING BEHAVIOR OF THE RAM IN THE ONE-SIRE PEN. C. V. Hulet*, S. K. Ercanbrack, D. A. Price, R. L. Blackwell and L. O. Wilson, *U.S.D.A., A.R.S. Animal Husbandry Research Division, Dubois, Idaho.*

Thirty-two breeding pens containing one ram and 18 to 38 ewes each were observed continuously for seven-day periods for mating and related activity in late fall at Dubois, Idaho. Variation in air temperature, wind velocity, cloud cover, precipitation, brightness of moonlight, type of artificial light at night (sealed beam spotlight or infrared illumination), age, inbreeding, body weight, semen score and previous use had no important influence on mating behavior. Rambouillet rams appeared to be more active than the Targhees and Targhees more active than the Columbias. Number of ewes in heat and individual ram differences independent of number of ewes in heat were the most important factors affecting mating behavior in the ram. Means and among-ram standard deviations (in parentheses) for various traits observed during breeding when one, two or three ewes respectively, were in heat are: teases/hour 0.95 (.32), 1.45 (.53), 2.31 (1.25): mounts/hour 1.35 (1.05), 2.14 (1.72), 3.58 (3.47): matings/hour 0.34 (.10), 0.55 (.24), 0.98 (0.59): minutes lying down/hour 22.46 (5.14), 17.59 (7.40), 15.59 (9.12): minutes eating/hour 9.46 (2.80), 8.57 (3.71), 8.50 (3.77): and mounts/mating 4.75 (5.97), 4.31 (4.26), 4.63 (5.16). Number of matings was moderately to highly correlated with the other mating behavior traits.

Mating behavior traits were not significantly correlated with fertility. Rams were much more active for several hours immediately after introduction into breeding than later. Stimuli as initial introduction into breeding, number of ewes in heat and feeding had greater influence on mating behavior than hour of day or amount of light.

297. MATING BEHAVIOR IN SHEEP. PART II. MATING BEHAVIOR OF THE RAM IN THE MULTI-SIRE PEN. C. V. Hulet*, S. K. Ercanbrack, R. L. Blackwell, D. A. Price and L. O. Wilson, *U.S.DA., A.R.S., Animal Husbandry Research Division, Dubois, Idaho.*

Seven breeding pens containing varying numbers and combinations of yearling and mature rams each 48 hours were observed continuously for 8 days. When a particular combination of rams was placed in a pen the dominance of one ram over another was quickly established. The dominant ram largely controlled the activity in the pen under most conditions. However, when more than one ewe was in heat especially when three rams were in the pen the dominant ram often found it difficult to completely curtail the mating activity of the inferior ram or rams. The presence of subordinate rams in a pen increased the total number of matings but reduced the average number of matings per ram below that of the pens containing only one ram. The average number of matings per ram for the dominant ram in combination pens was just equal to the average number of matings in the single ram pens. The greater the dominance of one ram over another the less the total mating activity and especially the mating activity of the subordinate ram. Dominant rams quite consistently were more successful in completing copulation than subordinate rams (6.3 versus 12.4 mounts per mating). Mature rams were always dominant over yearling rams and were more dominant over yearling rams than were yearling rams dominant over other yearlings. Mature rams tended to be less dominant over other mature rams than were yearlings over yearlings.

298. MATING BEHAVIOR IN SHEEP. PART III. MATING BEHAVIOR OF THE EWE. C. V. Hulet*, R. L. Blackwell, S. K. Ercanbrack, D. A. Price and L. O. Wilson, *U.S.D.A., A.R.S., Animal Husbandry Research Division, Dubois, Idaho.*

A total of 173 ewes in 24 one-sire breeding pens were observed continuously for one estrous period. Ewes frequently initiated the first sexual contact by seeking out the ram. In general, ewes would follow the rams about while in heat. When two or more ewes were in heat simultaneously certain ewes would bunt or crowd other estrual ewes out of position in an attempt to gain the ram's attention. Unweighted means and within pen standard deviations (in parentheses) for various mating behavior characteristics were: times teased 17.8 (7.0), times mounted 25.2 (14.4), times mated 6.3 (3.8), matings first half of estrus 3.9 (2.8) and matings second half of estrus 2.4 (1.7), hours first to last tease 27.6 (13.9), hours first to last mount 18.9 (8.5), hours first to last mating 15.7 (9.1), hours first tease to first mount 3.5 (6.8), hours last mount to last tease 5.0 (7.4). Age had no significant effect on any of the above variables but was positively related to number of lambs born. The more highly inbred ewes had longer estrus periods than the less highly inbred ewes. The time interval from first tease to first mount was longer for the heavier ewes after accounting for association between age and weight. As the number of ewes in heat increased the numbers of teases, mountings and matings per ewe declined as did hours from first to last mount, hours first to last mating and matings first half of heat. Hours from last mount to last tease was the only mating behavior characteristic significantly correlated with number of lambs born. The times at which ewes exhibited first and last evidence of estrus appeared to be more closely associated with management routine than time of day per se.

299. MORPHOLOGICAL STUDIES ON THE CORPORA LUTEA OF MULTIOVULATED BOVINE OVARIES. W. L. Hunt*, *Washington State University, Pullman.*

Three-hundred-seventy-two corpora lutea on 58 fixed pairs of super-ovulated bovine ovaries were selected through records of daily palpations and grouped as 1 to 2, 3 to 4, 5 to 6, 7 to 8 days old. Depth and diameters of corpora lutea and cavities present were measured. Mean corpora lutea depths for the successive age groups were 8.7 mm., 12.5 mm., 17.2 mm., and 20.4 mm. Mean corpora lutea diameters for the successive age groups were 6.2 mm., 10.8 mm., 14.1 mm., and 15.3 mm. The means for depth were significantly different ($P<0.01$) as were the means for the diameters, indicating the technique to be practical. Multiple range analysis indicated corpora lutea depth increased significantly between each of the four 2-day age groups ($P<0.01$), while each of the mean diameters increased significantly only up to the 5- to 6-day age. These data indicate that a growth curve for corpora lutea of this nature would be a reliable index. Percentages of corpora lutea containing fluid centers were 2% (1 to 2 days), 17% (3 to 4 days), 32% (5 to 6 days), and 71% (7 to 8 days). Both mean depth and mean diameters of the fluid centers increased almost linear with corpora lutea age. Eighty (21.5%) of these corpora lutea exhibited hemorrhagic areas.

300. RADIOISOTOPE LABELING OF SPERM IN BULLS AND RABBITS. E. W. Hupp*, J. W. Austin and R. L. Murphree, *UT-AEC Agricultural Research Laboratory, Box 1067, Oak Ridge, Tennessee.*

Six Hereford bulls were dosed subcutaneously, intravenously or intrascrotally with 10 to 20 μc. P^{32} per kg. body weight. Two bucks were dosed with 100 μc. tritiated thymidine and two with 40 μc. P^{32} per kg.; one member of each pair was dosed intrascrotally and the other intravenously. Three ejaculates were obtained from each bull 3 times each week by electroejaculation; single ejaculates were obtained twice weekly in an artificial vagina from each buck. Radioactivity in twice washed bovine and rabbit sperm and the DNA of bovine sperm was determined with a liquid scintillation spectrometer. The data indicate that route of administration did not affect the efficiency of incorporation or pattern of ejaculated activity of either isotope. While some radioactivity was noted in sperm from P^{32} dosed bucks and from bulls before the main peak of activity, none was noted in the sperm from tritiated thymidine dosed

rabbits or in the DNA from bovine sperm. The initial rise of the main peak of radioactivity began 48 to 51 days after dosing in bulls and 42 to 48 days after dosing for both isotopes in the bucks. Level of radioactivity reached a maximum 55 to 65 days after dosing in bulls and between 53 to 63 days in the bucks, then began to decline. Radioactivity in sperm of tritiated thymidine dosed rabbits declined more rapidly than those dosed with P^{32}. Level of radioactivity in the sperm of tritiated thymidine dosed rabbits indicates lower doses than those used will give satisfactory labeling.

301. FUNCTIONAL CAPABILITIES OF EXPERIMENTALLY INDUCED CORPORA LUTEA IN EWES. E. K. Inskeep*, M. M. Oloufa, A. L. Pope, and L. E. Casida, *University of Wisconsin, Madison.*

The length of the estrous cycle or interval to next ovulation was used as a measure of the functional life span of corpora lutea in mature ewes. In control ewes (two per stage) removal of natural corpora lutea from the ovaries at laparotomy on day–4, –8, or –12, caused return to heat in 2 to 3.5 days. Two groups of experimental ewes were ovulated by an intravenous injection of unfractionated pituitary extract just prior to laparotomy at day–4, –8, or –12. One of the groups (four to five per stage) received no further treatment except both natural and induced corpora lutea were marked with India ink for later identification. In the second group of four to five ewes per stage, the original glands were removed completely at laparotomy and the induced corpora lutea were marked and left in the ovaries. Thirty-two control cycles of the above ewes averaged 17.0 days. Experimental cycle lengths in group 1 were: at day-4, 16.5 to 18 days for four ewes; at day-8, 18 days each for four ewes; and at day-12, 16 to 20 days for five ewes. When new glands were added and natural corpora lutea removed (group 2), experimental cycle lengths were: at day-4, 16.5 to 18.5 days for three ewes and 7 days for one ewe; at day-8, 13 to 16 days for five ewes (two of these had quiet ovulations); and at day-12, 14 to 15 days for four ewes. A fifth ewe had not shown heat when killed at 18.5 days and her induced corpora lutea still appeared functional.

302. EFFECTS OF TEMPERATURE AND CONTROLLED FEEDING ON MILK PRODUCTION AND RELATED PHYSIOLOGICAL REACTIONS IN CATTLE. H. D. Johnson*, O. Wayman, H. H. Kibler, A. C. Ragsdale, I. L. Berry, C. P. Merilan, *University of Missouri, Columbia.*

High environmental temperatures depress feed intake of cattle. What are the results of maintaining a constant fed intake when cattle are exposed to higher environmental temperatures (88° F.)? To gain this information six lactating Holstein cows (four fistulated-control-fed and two *ad libitum*) in a switch-back experimental design were exposed in the Missouri Climatic Laboratory for 3-week periods alternately to 65° F.–50% R.H., 88° F.–50% R.H., 65° F.–50% R.H. etc. The average decline in milk production (lb/day) at 88° F. for ad libitum cows was 7.30 and 4.73 lb. for control-fed animals. Ad libitum third week exposure values (difference between 65° F. and 88° F. conditions) for rectal temperatures (°F.), H_2O consumption (lb./day), body weight (lb./day), respiratory rates (counts/min.), and energy metabolism (Cal./hr.), were +2.55, −23.4, −35.50, +28.84, −182.67 and control fed values were respectively +2.62, +27.7, +58.41, +34.21, +19.08. The number of calories (heat production) expended per unit of 4% FCM milk produced was generally greater at 88° F. than 65° F. This is more apparent in the *ad libitum* animals. Heat production per unit TDN consumption was greater for ad libitum cows at 88° F.—than at 65° F. Controlled feeding by cannula will contribute valuable insight into the temperature-nutrition complex in the field of environmental physiology.

303. LIOTHYRONINE AND IODINATED-CASEIN TREATMENT OF LACTATING EWES. R. M. Jordan*, *University of Minnesota, St. Paul.*

Four experiments were conducted to determine the effect of altering thyroid activity of lactating ewes on the weight gain of suckling lambs. In experiment 1, Hampshire ewes suckling single Southdown X Hampshire crossbred lambs were implanted subcutaneously with six, 5 mg. implants of liothyronine when the lambs were approximately 10 days old. In experiment 2, mature Southdown ewes, suckling single lambs primarily, were implanted subcutaneously with five, 5 mg. implants of liothyronine when the lambs were approximately 10 days of age. In experiment 3, mature Hampshire ewes, suckling twin lambs, were implanted with four, 10 mg. implants of liothyronine when the lambs were approximately 3 weeks of age. In experiment 4, mature Southdown ewes, suckling either twin or single lambs, were implanted subcutaneously with four, 10 mg. implants of liothyronine or were fed 2 grms. of iodinated-casein per ewe daily. All experiments were conducted in dry lot with the exception of experiment 4 in which the lambs were placed on brome grass pasture during the last 3 weeks. Average daily gains of lambs were: experiment 1, control, 0.54 lb., liothyronine 0.46 lb.; experiment 2, control, 0.51 lb., liothyronine 0.49 lb.; experiment 3, control, 0.64 lb., and liothyronine 0.65 lb.; and experiment 4, control, 0.45 lb., liothyronine 0.42 lb. and iodinated-casein 0.38 lb. Weight gain differences between treatments were not significant. Ewe weights were not affected by liothyronine treatment but weight losses occurred in the ewes fed iodinated-casein. Some iodinated-casein feed intended for their dams was eaten by the lambs.

304. EFFECTS OF INTRAPERITONEAL INJECTION OF CALCIUM GLUCONATE ON BOVINE BLOOD SERUM COMPOSITION. K. A. Kendall* and K. E. Harshbarger, *University of Illinois, Urbana.*

Eight aged dairy cows, without previous milk fever histories, were each injected intraperitoneally through the right paralumbar fossa with 500 ml. of a 27.3% calcium aluminogluconate solution within 30 minutes after parturition. Blood samples were taken daily for 6 days and within 3 hours of parturition and also within 30 minutes, 2, 4, 6, 12 and 18–24 hours after parturition. Post-injection blood serum calcium levels of 11.2, 12.0, 11.9, 11.2 and 10.3 mg. per 100 ml. respectively as observed at 2, 4, 6, 12 and 18–24 hours, were 16% higher than the average calcium levels observed in the 27 non-injected control cows during the same period. Postpartum in-

organic phosphorus levels were slightly lower in the injected cows as compared with those of non-injected cows. A maximum serum total reducing substance (T.R.S.) level of 72.8 mg. per 100 ml. was observed in the non-injected cows within 2 hours after calving as compared with prepartum levels of 45–50 mg. per 100 ml. for both groups. In the injected cows, T.R.S. levels reached 82 mg. per 100 ml. of serum within 2 hours after parturition.

305. SAMPLING BOAR TESTES TO QUANTITATIVELY STUDY SPERMATOGENESIS AND SPERM PRODUCTION. J. J. Kennelly* and R. H. Foote, *Cornell University, Ithaca, New York.*

Four predetermined areas of boar testes were sampled to determine if each location provided a representative sample. Such information is essential for evaluation of testicular function and for prediction of sperm production from histological preparations. Six 2-year-old boars (group I) and nine 1-year-old boars (group II) were sampled. Chalkley's method of estimating relative volume percent was used to insure random sampling of the testis. Four thousand observations were made per boar. The mean volume percents of the elements classified for group I boars were: spermatogonia, 1.4; primary spermatocytes, 3.8; Sertoli cells, 1.2; unclassified nuclei, 10.5; total tubular cytoplasm, 38.4; lumen, 11.6; basement membrane, 3.4; total tubule, 70.4; non-tubule, 29.6; and artifacts, 5.4. The group II mean percents were: spermatogonia, 1.0; primary spermatocytes, 2.7; total tubule, 77.5; non-tubule, 22.5; and artifacts, 5.6. Group I boars differed significantly ($P<.05$) with respect to spermatogonia, unclassified nuclei, total tubular cytoplasm, total tubule, non-tubule, and artifacts. Similarly the four locations sampled differed significantly ($P<.05$) with respect to lumen and total tubule, while left and right testes showed no significant differences. In group II, boars differed significantly ($P<.05$) with respect to total tubule, non-tubule, and artifacts. The number of primary spermatocytes per boar was estimated, and this value, together with other information, can be used to estimate potential sperm production.

306. PHYSIOLOGICAL RESPONSES TO THE INGESTION OF COLD WATER BY SHEEP. M. A. MacDonald* and A. M. Hicks, *Macdonald College (McGill University), Quebec, Canada.*

The effects of ingestion of volumes (1.0, 1.5 and 2.0 litres) of water at various low temperatures (5°, 10° and 15° C.) on rumen, rectal and skin temperatures of sheep, were studied using a 4 x 3 x 3 factorial design which was conducted in moderate (14° C.) ambient air temperatures. The experiment was repeated in colder (—9.5°) ambient air temperatures. Rumen, rectal and skin temperatures were recorded continuously for 200 minutes following each treatment, using a commercially available single channel laboratory recorder converted to a 12 channel recorder by the inclusion of a 12 channel switch and a synchronous motor within its circuit. Rumen and rectal temperatures rose to an afternoon maximum followed by a decline at night. Both rumen and rectal temperatures were significantly higher (1° C.) and surface temperatures significantly lower (0.3° C.) at the lower ambient temperatures. Water intake reduced rumen temperatures 6° C. to 12° C. in both moderate and cold ambient air environments, and reduced rectal temperatures 1° C. and 0.5° C. in moderate and cold ambient air temperatures respectively. Return of both rumen and rectal temperatures to former values was more rapid in cold than moderate ambient air temperatures. Shivering was observed when the largest volumes of the coldest water only was ingested in moderate ambient temperatures, but occurred following all treatments in the colder ambient air temperatures. It is hypothesized that initiating shivering originated in the rumen wall.

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309. ESTRUS AND FERTILITY IN BEEF CATTLE SUBSEQUENT TO THE ORAL ADMINISTRATION OF 6-METHYL-17-ACETOXYPROGESTERONE. G. E. Nelms* and Weslie Combs, *University of Wyoming, Laramie.*

Three trials were conducted to evaluate the effect of orally administered ó-methyl-17-acetoxyprogesterone (Provera, The Upjohn Co.) on estrus and fertility in beef cows. In Trial I, 10 dry mature cows received 0.8 mg. of 6-methyl-17-acetoxyprogesterone per pound body weight per day, by individual twice-a-day feeding, for 15 days. Weights of the cows ranged from 850 lb. to 1250 lb. Nine of the 10 cows came into heat on the third, fourth, and fifth day following the removal of the hormone. Six of the 10 cows calved as a result of breeding at the synchronized estrus. In Trial II, 33 cows with calves received 220 mg. of 6-methyl-17-acetoxyprogesterone per day by twice-a-day feeding for 15 days. Estrus occurred in all cows on the second and third day after the removal of the hormone. Eighteen of the cows were part of another experiment and were not available for a fertility check. However, of the remaining 15, 10 were diagnosed as pregnant to the first estrus following treatment. In Trial III, 60 2-year-old heifers were group fed at a level of 250 mg. per day for 14 days. Each heifer was inseminated on the third, fourth, and fifth day following the removal of the treatment without observing for estrus. It was observed however, that the heifers started coming into heat on the second day. Forty percent were diagnosed as pregnant. No attempt was made to breed the heifers on subsequent cycles. This conception rate was comparable to the rate attained in 60 controls during the first 21 days of insemination.

310. EFFECT OF UTERINE DISTENTION ON THE ESTROUS CYCLE OF THE MATURE EWE. M. M. Oloufa, E. K. Inskeep*, A. L. Pope and L. E. Casida, *University of Wisconsin, Madison.*

Two groups of five ewes each were treated by implanting a 7 mm. plastic bead into one uterine horn, on day-3 of the estrous cycle in one group and on day-8 in the other group. Observations for estrus was made twice daily. Two day-3 ewes had "implantation" cycles of 6.0 and 6.5 days followed by second cycles of 5.0 and 8.5 days; while both implantation and second cycles were normal in the

other three ewes. The mean implantation-cycle length for the group was 11.5 ± 2.2 days. All day-8 ewes exhibited normal implantation-cycle lengths, except that one ewe which had not shown estrus when autopsied on day-21, appeared to have ovulated quietly at about day-17. One day-8 ewe had second and third cycles of 7.5 and 8.5 days, respectively, similar to the "day-3" effect. The mean implantation-cycle length for the day-8 group was 16.9 ± 0.2 days. Three unaffected ewes from each group were reimplanted into the opposite uterine horn with beads (11.5 mm.) on day-3. Two of these exhibited implantation cycles of 6 and 8 days, three had normal cycles, and one had a quiet ovulation, estimated at autopsy to have occurred at 6 to 8 days. The mean implantation-cycle length for the six ewes was 11.9 ± 2.2 days. These data agree with those of Nalbandov *et al.* (Endoc., 56:225, 1955) as to the effect of a bead placed in the uterus on the third day of the estrous cycle. However, the lengthening effect noted by the above workers when the implantation was made on the eighth day of the cycle was not confirmed.

311. EFFECT OF DIET AND AGE ON DEVELOPMENT OF PANCREATIC DIGESTION IN THE EARLY POST NATAL PIG. J. C. Pekas*, V. W. Hays, A. N. Thompson, V. C. Speer and J. T. McCall, *Iowa State University, Ames.*

Two experiments were conducted using a factorial design involving 64 baby pigs, two experimental diets (soybean protein and dried skimmilk protein), two pancreatic treatments (pancreatic ducts ligated (PDL) vs. sham operated controls (SOC)), and two or three age groups of animals (2 to 8 wks.). Protein digestibility, dry matter digestibility, nitrogen retention, and protein biological value were all reduced by PDL as compared to the SOC animals. The magnitude of the reduction caused by PDL generally decreased with advancing age for pigs on the dried skimmilk protein diet and increased for pigs on the soybean protein diet. Thirty-two pigs were sacrificed at the conclusion of the collection period and examined for gross lesions resulting from the surgical procedures or alterations. Except for minor intestinal adhesions at the laparotomy site no gross abnormalities were observed. Pancreatic tissue appeared normal for the SOC animals when examined histopathologically, however, the same tissue from PDL animals manifested atrophy and fibrosis, dilated pancreatic ducts, reduction in number and prominence of acini, slight lymphocytic infiltration and mild degeneration of islet of Langerhans in the older animals. In the younger group of animals islets of Langerhans were observed in 2 of 15 animals.

312. A COMPARISON OF THE TSR OF BEEF AND DAIRY CATTLE. G. W. Pipes*, J. E. Comfort, T. R. Bauman, and C. W. Turner, *University of Missouri, Columbia.*

Thyroxine secretion rate (TSR) of dairy cattle has been studied in our laboratory (Mo. Res. Bul. 617 and 727). During the winter 6 months individual estimations ranged from 1 to 10 mg. thyroxine/1000 lb. body weight per day with a mean of 5.4 mg. During the summer 6 months there was about a three-fold decline with range of 1 to 4 mg./1000 lb. body weight with a mean of 2.0 mg. Other factors influencing the TSR of dairy cattle have been studied. TSR of beef cattle has not been reported previously. During the winter and spring TSR of 57 beef cattle of various breeds, ages and conditions have been determined. They range from 1 to 5 mg. thyroxine/1000 lb. body weight with a mean of 2.61 mg. To give a preliminary indication of seasonal effect, a group of 16 Angus and Shorthorn heifers showed a mean TSR of 3.1 mg. on May 5. On June 24 this same group had declined to 1.9 mg./1000 lb. body weight, a decline of about 1/3. A further decline is expected during July and August when environmental temperatures are highest. These preliminary data indicate that the mean winter TSR of beef cattle is about ½ that of dairy cattle and that higher environmental temperatures tend to depress the secretion rate.

313. THYROXINE IMPLANTATION AND THYROIDAL-I^{131} RELEASE IN CATTLE. B. N. Premachandra and C. W. Turner, *University of Missouri, Columbia.*

The role of the thyroid gland in maintaining the intensity of milk secretion has been well recognized, as shown by either thyroidectomy or by administering the hormone of the thyroid gland, thyroxine. The hormone has been administered orally in cattle, but there is a great loss of the hormone in the digestive tract and only a small proportion is available to the body. The implantation of thyroxine pellets would serve as a practical alternative procedure if it could be shown to be effective. Radioactive iodine (I^{131}) was used in the present investigation to study the effectiveness of thyroxine implantation. Three bull calves were injected with 300–500 uc I^{131}. Thyroidal-I^{131} and thyroxine secretion rates were determined by methods described previously (Pipes *et al.*, J. Dairy Sci. 40:340, 1957). 4 g. tapazole/1000 lb. bodyweight were administered in all the animals to prevent thyroid reutilization of I^{131} from the degraded-labeled hormone, thus facilitating a true release rate of the hormone. One week after obtaining thyroxine secretion rates I^{131} was again administered and the true release of I^{131} by the thyroid gland established. The calves were then implanted with thyroxine pellets equivalent to their estimated thyroxine secretion rates. Within 24–48 hours a sufficient amount of the implant was absorbed so as to cause a reduction in thyrotropic hormone secretion (TSH) shown by progressive inhibition of thyroidal-I^{131} release. A single implant of daily thyroxine secretion equivalent pellet exerted the effect between 3–6 days, after which the effectiveness was lost, shown by resumption of thyroidal-I^{131} release.

314. FOAMING PROPERTIES OF ALFALFA AND THEIR RELATIONSHIP TO BLOAT. R. Pressey*, S. H. Synhorst, Janet Bertram, R. S. Allen and N. L. Jacobson, *Iowa State University, Ames.*

A conventional technique for measuring foam stability was adapted for studying the foaming properties of alfalfa and their alteration by rumen microorganisms. Samples of alfalfa were collected from plots grazed by cattle, and their foaming properties were determined under fixed conditions. On a fresh-weight basis, a relationship between the foaming properties and the bloat-promoting potential of the alfalfa was observed. Daily studies of plots in-

dicated that the general pattern of variation consisted of a gradual increase as growth progressed with a decrease near the bloom stage but deviations, due in part to variations in soil moisture, were common. The foaming properties of the alfalfa extracts were highly dependent on the temperature and pH of the macerating medium, with a temperature optimum at 18° C. and a pH optimum at 6.2. In contrast, a given extract was affected only slightly by changes in pH subsequent to extraction. The foaming properties were associated primarily with the leaves and were increased up to 50% by freezing a sample before macerating, but lyophilizing an extract had no effect. During extraction of lyophilized extracts with organic solvents, an alcohol-soluble foam inhibitor was detected. Incubation of the lyophilized extracts with rumen microorganisms showed that this inhibitor is rapidly destroyed, while the foaming agents are only slowly degraded. The results suggest that the bloat-producing potential of a plant is the net effect of a delicate balance of foaming agents, foam stabilizers and foam inhibitors.

315. BLOOD UREA IN CATTLE AS AFFECTED BY ENERGY, PROTEIN AND STILBESTROL. R. L. Preston*, L. H. Breuer and G. B. Thompson, *University of Missouri, Columbia.*

It is known that energy, protein and stilbestrol may affect blood urea levels in ruminants. Blood urea levels were compared in 650 lb. steer calves after feeding for 147 days on three levels of energy-fullfed corn, corn silage and supplement (FF), 100% NRC fattening (HE), and 100% NRC wintering (LE); and two levels of protein—100% NRC fattening (HP) and 75% NRC wintering (LP). Twelve steers were used per treatment. Results at the end of the 147-day period were as follows (in mg. urea-N/100 ml.): HEHP-11.84; HELP-4.23; LELP-7.35; FFHP-8.76. At this time the steers were all placed on a full feed of ear corn and supplement. Half of the steers on each of the previous treatments were implanted with 36 mg. DES. After 28 days, the non-implanted steers showed the following blood urea-N levels respectively: 7.66, 7.58, 4.21 and 7.41; and after 84 days they were respectively: 12.06, 12.33, 11.39, 13.92. The implanted steers after 28 days were respectively: 4.78, 3.94, 3.22 and 5.83; and after 84 days they were respectively: 10.40, 11.15, 11.15 and 12.85. DES decreased blood urea after 28 days compared to the previous bleeding in all groups except those previously fed LELP, when comparisons were made within implant groups. After 84 days only those previously fed FFHP were decreased with DES; steers previously fed LELP showed an increase with DES. These changes did not reflect the magnitude of gain stimulation from DES, which was greatest at 28 days in steers previously fed HEHP and FFHP. At 84 days, DES increased gains 31, 15, 17 and 16% respectively in those steers previously fed HEHP, HELP, LELP, FFHP.

316. ESTRUS AND URINARY ESTROGEN EXCRETION IN THE SOW. James I. Raeside*, *Ontario Veterinary College, Guelph, Ontario, Canada.*

A chemical method for measuring urinary estrogens in the sow has been developed. With it the time relationship between estrus and urinary estrogen excretion was investigated. Preliminary studies had indicated that the peak in urinary elimination of estrogens occurred before or at the onset of estrus. Urine was collected continuously for three or four days from three sows by means of an indwelling catheter in the bladder. Estrogen determinations were made in duplicate on 500 ml. urine samples representing each 8-hour period during collection. In each animal the peak excretion of urinary estrogens was seen near the onset of estrus with a sharp decline subsequently. The evidence suggests a preovulatory fall in estrogen production in the sow.

317. FACTORS AFFECTING BLOOD VALUES IN BEEF CALVES. B. J. Rankin*, E. J. Turman, B. J. Watkins, *Oklahoma State University and Animal Husbandry Research Division, ARS, USDA, Stillwater.*

Osmotic fragility, hematocrit and hemoglobin concentration were measured on 246 calves at less than one week of age, and the effects of dwarfism genotype, breed, sex, age and birth weight on these measurements were studied. Results indicated: (1) There was no significant difference in osmotic fragility between carrier and clean calves, but dwarfs were significantly higher in fragility than normal calves. (2) Carriers were significantly higher in hematocrit values than clean calves, and dwarfs were slightly higher than carriers. (3) Carriers were significantly higher in hemoglobin concentration than clean calves, yet dwarfs were no higher than carriers. (4) Angus calves were significantly higher than Herefords in fragility, hematocrit and hemoglobin values, and crossbreds were intermediate in all three values. (5) Among Herefords, males were significantly higher than females in fragility, hematocrit and hemoglobin. The effect of sex was not significant in Angus and crossbreds. (6) Birth weight had no effect on fragility, but hematocrit and hemoglobin increased significantly as birth weight increased. (7) As age increased from birth to seven days, osmotic fragility increased and hematocrit and hemoglobin concentration decreased. (8) None of the three blood measurements studied proved useful for classifying clean and carrier calves. The effect of injection of 0.4 cc. of epinephrine (1:10,000) per 100 lb. of body weight on osmotic fragility was studied in 11 carrier and 11 clean calves. No significant difference was found between the two groups.

318. RESPONSE OF GROWING CALVES ON TWO PROTEIN LEVELS TO EXCESS DIETARY MANGANESE. N. W. Robinson*, S. L. Hansard, D. M. Johns and G. L. Robertson, *Louisiana Agricultural Experiment Station, Baton Rouge.*

Clinical changes in peripheral blood, periodic balance studies, and terminal tissue analyses supplemented weight gain and feed efficiency response measurements of cattle to high and low protein Bermuda grass hay rations containing 0, 300 and 600 ppm manganese. The results of this investigation with 60 calves fed in six lots for 180 days indicated: (1) no significant differences between treatments in RBC or hemoglobin, plasma, calcium, phosphorus, magnesium, iron, protein, vitamin A, or carotene; (2) more phosphorus and iron were absorbed by animals on the higher protein rations and more were excreted at the higher manganese levels; (3) termi-

nal tissue analyses showed increased manganese storage and iron depletion with increased manganese intake. Dietary protein levels fed were without effect. No pathological changes in tissue or organs were evidenced; (4) a trend toward increased liver carotene and decreased vitamin A with increased dietary manganese was observed; (5) weight gains and feed efficiency were increased at the higher protein levels and added manganese had no significant effect. Data indicate excess manganese effects to be less at the higher dietary levels and to be greater on function than tissue structure.

319. EFFECT OF WETTING RAMS ON RECTAL TEMPERATURES AND RESPIRATION RATES. C. V. Ross* and M. G. Moose, *University of Missouri, Columbia.*

Nine trials were conducted to study the effects of spraying and dipping on rectal temperatures and respiration rates of nine Hampshire rams kept in a room heated to approximately 95° F. In each trial, three rams were sprayed and three were dipped for ¼, 2, or 10 minutes with 68–71° F. water. In the course of the trials, each ram received all six treatments and served as a control in three trials. Rectal temperatures and respiration rates were taken just prior to the water treatment. Rectal temperatures were recorded at intervals of 20 minutes and respiration rates at 40 minutes for 160 minutes after treatment. Dipping rams in water 70° F. resulted in an immediate and prolonged reduction of body temperatures and respiration rates. Rams dipped in water had significantly lower ($P<.01$) body temperatures and respiration rates than those on the other treatments. Compared with controls, dipping for 10, 2, and ¼ minutes lowered the body temperatures 1.1°, 0.9°, and 0.8° F. respectively and slowed respiration rates 47.5%, 50.5%, and 38.6% respectively. In one trial, time was extended, and the ram dipped for 10 minutes required 4 hours to return to the initial temperature. Rams sprayed for 10 minutes had significantly lower ($P<.01$) respiration rates than those sprayed for ¼ minute. Spraying only slightly reduced body temperatures or respiration rates below controls.

320. THE INFLUENCE OF THYROXINE IMPLANTS ON LAMB AND WOOL PRODUCTION. Maurice Shelton*, *Texas Agricultural Experiment Station, McGregor.*

A number of field trials were conducted in which 60 and 90 mg. implants of L-thyroxine was implanted subcutaneously on the side approximately two inches below the midline of finewool ewes. Control groups were maintained in all cases. The total numbers involved were 147 treated and 155 control. The treatments applied resulted in increased body temperature and respiratory rate and reduced body weights as compared to controls. These differences were significant and continued for a period of approximately 6 weeks after implantation. The treated animals produced significantly more grease wool. However, the difference was on the order of 0.2 lb. per head and thus of questionable economic importance. Fertility data were calculated based on a six weeks breeding season. Differences in ewes lambing or lambs dropped were not significant. Among three groups in which the breeding season started at or within two weeks after treatment, there appeared to be a reduction (11%) in percent of ewes lambing. Four groups involving 88 controls and 74 treated ewes were treated six weeks or more before the start of the breeding season. The percent ewes lambing and percent lambs dropped of ewes lambing of the two groups were; controls—85.6 and 144.2; thyroxine treated 83.1 and 158.3. In two of the four trials in which the treatments started six weeks or more before the start of the breeding season, the thyroxine implants appeared to increase the proportion of ewes giving birth to twins.

321. METHYLENE BLUE REDUCTION BY BULL SEMEN. R. L. Shirley*, T. N. Meacham, A. C. Warnick, J. F. Hentges, Jr. and T. J. Cunha, *University of Florida, Gainesville.*

Four 8-month old bulls were fed a ration containing the N.R.C. recommended level of dietary protein and eight corresponding bulls were fed 11.7% of this amount of protein. After 3 months on the rations the semen was tested for rate of methylene blue reduction. On pooled samples of the first ejaculation of a series the semen from the low protein group required three times as long to decolorize the dye as that from the full-fed bulls; while the time required for the corresponding semen from the fourth ejaculation was the same for the two groups. Succinate and glutathione added to the semen decreased the reduction time to about half for the first ejaculation, but had little effect on the fourth ejaculation. Thioglycollic acid decreased the reduction time more than 90% and erased the difference between the two dietary groups. Cysteine and iron also stimulated reduction; but calcium, magnesium, aluminum and adenosinetriphosphate had no effect. Copper prevented any reduction of the methylene blue over a 24-hour period.

322. RECTAL TEMPERATURE AND RESPIRATION RATE IN THE GROWING LAMB. R. H. Simms* and F. N. Andrews, *Purdue University, Lafayette, Indiana.*

The rectal temperature and respiration rate measurements of newborn and growing lambs were collected during two successive lambing seasons. More than 3,000 observations were recorded from 108 Purebred Southdown, Shropshire, Hampshire and Rambouillet lambs. Determinations were made from birth until the end of the fourth post-natal week during February, March and April. The rectal temperature at birth was similar to that of the parturient ewe. The average rectal temperature of all lambs at birth was 103.29° F., but declined following parturition to a value of 102.22° F. at the 48th post-natal hour. The rectal temperature rose after the second day to a value of 102.84° F. on the fifth post-natal day. There was a rather narrow fluctuation of rectal temperature values during the second, third and fourth weeks of the lamb's life. The decline and subsequent rise in rectal temperature following birth was significantly different ($P<0.01$). An analysis of the Southdown and Hampshire data showed no significant breed or sex differences in rectal temperature at birth, four or 48 hours. Similarly to the rectal temperature values, the respiration rate declined following parturition. The respiration rate declined from 68.4 at birth to 57.6 at 48 hours which was significant ($P<0.01$). There is an apparent stabilization of the respiration rate

in lambs at about 3 days of age. From the results of this study we would agree with previous authors who acknowledged that the respiration rate is a less reliable index of the individual's thermal stress than is the rectal temperature.

323. TEMPERATURE OBSERVATIONS IN THE BOVINE BY IMPLANT TELEMETRY. Vearl R. Smith* and Howard A. Baldwin, *University of Arizona, Tucson.*

Studies of the ability of the bovine to regulate heat have been undertaken using radio telemetry of temperature from an implanted transmitter. The instrument employs thermister sensing to change the modulation tone of an FM transmitter. The implanted unit is approximately 2 cu. in. in volume and provides a range of 25 to 50 ft. depending on the battery power employed. The radio signal is received by a standard FM radio receiver, decoded and continuously recorded. The instrument is sensitive to 0.1° F. Variations in the internal temperature of the animal as a result of the external heat load and muscular activity are rapidly and conveniently recorded. A technique has been developed for implantation of the transmitter in the cow by the use of sutures attached to the neck of the cervix. Once the attachment has been made the transmitter may be implanted or removed from the cow under study with ease. Investigation of the diurnal range of internal temperature has been undertaken and compared to data obtained from rectal thermometers. Studies are in progress that will attempt to assess the temperature regulating ability of the cow under a variety of heat loads.

324. CALCIUM CHELATION WITH DAIRY COWS. Vearl R. Smith* and W. H. Brown, *University of Arizona, Tucson.*

Lactating and dry cows were intravenously infused with a 10% solution of ethylenediaminetetraacetic acid (EDTA). The EDTA was administered at a constant rate until the cow developed tetany. Blood samples were drawn before chelation, at 45 minutes, 1½ hours, 2¼ hours, when tetany occurred and 3, 4, 6, 8, 10, 12, 14 and 24 hours after the beginning of the infusion. The blood was analyzed for calcium, inorganic phosphorus and magnesium. Total leucocytes were counted in a hemacytometer with Neubauer rulings. Two smears were made from each sample and stained for a differential leucocyte count. The means were obtained from a total of 16 experiments. The blood serum calcium mean before chelation was 10.75 mg. percent. At tetany the mean blood serum calcium level was 4.78 mg. percent. The mean time for occurrence of tetany was between 2¼ and 3 hours after beginning of the infusions. At 24 hours the mean blood serum calcium was 9.78 mg. percent. The mean inorganic phosphorus level before chelation was 5.80 mg. percent. The low mean value, 3.48 mg. percent, for phosphorus occurred after tetany at the 4-hour sampling. At 24 hours the mean for phosphorus was 5.19 mg. percent. A diminution of lymphocytes and an increase in neutrophils occurred at the 3-hour sampling. At this time the neutrophils outnumbered the lymphocytes. By 24 hours the leucocyte count had returned to normal.

325. OVARIAN CHANGES IN HORMONE TREATED HYSTERECTOMIZED AND CYCLING GUINEA PIGS. H. G. Spies*, H. T. Gier, J. D. Wheat, *Kansas State University, Manhattan.*

Daily vaginal smears were taken on 48 virgin inbred guinea pigs with normal cycles and randomly assigned into 12 treatment groups. Corpora lutea were marked with carbon three to five days following ovulation and hysterectomy was performed on day 5 in four of the 12 groups. Progesterone (10 mg./kg. body weight subcutaneous daily), estradiol 17-cyclopentylpropionate (250 mcg./kg. of body weight intramuscular daily), and relaxin (5 mg. every other day intramuscular) were injected starting on day 6 after ovulation until autopsy on day 12 or 28 post estrus. The twelve treatment groups were: day 12 untreated, day 28 untreated, day 12 progesterone, day 28 progesterone, day 12 estrogen, day 28 estrogen, day 12 relaxin, day 28 relaxin, hysterectomized, hysterectomized plus progesterone, hysterectomized plus estrogen, and hysterectomized plus relaxin (hysterectomized groups sacrificed day 28). Pituitary weight (mg.), corpora lutea diameter (mm.) and average large lutein cell numbers for the 12 groups were 5.2, 1.17, 15.5; 5.8, 0.32, 1.2; 10.0, 1.14, 16.6; 8.5, 0.32, 1.2; 10.7, 1.17, 12.5; 11.0, 0.36, 1.4; 6.8, 0.75, 9.0; 10.8, 0.98, 6.0; 10.4, 1.71, 14.3; 7.9, 1.31, 10.4; 9.0, 1.49, 16.0; and 7.3, 1.39, 11.0, respectively. These three traits were significantly different among the groups ($P<.01$), but body weight, ovarian weight, and number of normal or atretic vesicular follicles were not. Hysterectomy prolonged luteal function. Progesterone and estrogen prevented ovulation in cyclic treated pigs, but did not affect the life of the corpus luteum. Relaxin caused an inconsistent effect independent of the uterus. Mitotic activity was observed in fully formed corpora lutea.

326. EXPERIMENTAL BOVINE SUPEROVULATION FOLLOWING SUPPRESSION OF OVARIES WITH ESTROGEN. T. Sugie and W. L. Hunt*, *Washington State University, Pullman.*

Six yearling Hereford heifers received superovulatory treatments involving 5,000 I.U. PMS injected subcutaneously followed in 5 days by intravenous injection of 2,000 I.U. HCG. Fifteen days prior to treatment 3 of the animals received ten daily 10-mg. intramuscular injections of 17β-estradiol in vegetable oil. Palpated ovaries reduced in size to minimum volume (average 2.8 cc.) on corresponding day following estrogen injections and grew to maximum size (average 19.5 cc.) on corresponding day following PMS treatment. In 3 controls the corpus luteum was expressed on day 16 of animal's estrous cycle and treatment began. All heifers were inseminated or mated daily while ovaries were believed to be ovulating. Slaughter of animals effected 5 days after ovulating dose given. Ovulation averaged 22 for estrogen treated animals and 27 for controls. Recovery was made of 33 eggs from estrogen treated animals, 29 being flushed from oviducts. Thirty-six eggs were recovered from the controls, five being flushed from the oviducts. Cleavage was observed in 19% and 39% of the eggs recovered from treated and controls, respectively. Although the treated ovaries were diagnosed as suppressed and in a non-

hormonal state, these data indicate that multiovulatory response was not altered effectively.

327. EFFECTS OF PRE-PARTUM GRAIN FEEDING ON LACTATION IN COWS. E. W. Swanson* and S. A. Hinton, *University of Tennessee, Knoxville.*

The effects of feeding about 300 lb. extra grain during the latter part of lactation compared to feeding it during the last 6 wk. of the dry period were determined with 70 cows paired on the basis of previous lactations. Paired cows were fed alike after calving. Those fed 8 lb. per day of grain for 37.6 days of the dry period gained 35 lb. more before calving than their pair mates. They produced 359 lb. more FCM in the first 15 wk. and 573 lb. more in the first 30 wk. of lactation than those not fed grain in the dry period. These differences were statistically significant. In another experiment with 40 pairs, grain feeding was compared to no extra grain feeding during the dry period or in lactation. Combining data from the 75 pairs showed that cows fed extra grain and those fed only *ad lib.* roughage in the dry period, respectively, averaged 4,664 and 4,362 lb. FCM in 15 wk. and 7,970 and 7,527 lb. FCM in 30 wk. lactation; 7,969 lb. and 7,522 lb. of milk; 320.1 and 300.9 lb. of butterfat in 30 wk. lactation. These production differences were statistically significant. Milk production and body weight changes during lactation indicate that grain feeding for 6 wk. prepartum stimulated a high initial lactation level, and that the high lactation was maintained at the expense of body weight gain longer than in cows which were not so stimulated.

328. SPERMATOGENESIS IN THE RABBIT. E. E. Swierstra* and R. H. Foote, *Cornell University, Ithaca, New York.*

The cycle of the seminiferous epithelium of the rabbit was divided into eight stages on the basis of the characteristics of successive associations of cell types. The criteria used were similar to those previously described by others for different species. Stage 1 extends from the absence of spermatozoa in the lumen to the beginning of the elongation of the spermatids. Stage 2 extends from the beginning to the end of elongation of the spermatids. Stage 3 extends from the end of elongation of the spermatids to the beginning of the first maturation division of the primary spermatocytes. Stage 4 extends from the beginning of the first maturation division to the end of the second maturation division. Stage 5 extends from the end of the second maturation division to the time when the spermatids show a dusty appearance. Stage 6 extends from the time the spermatids show a dusty appearance to the time the spermatozoa have separated from the Sertoli cells and move towards the lumen. Stage 7 extends from the beginning to the end of the movement of the spermatozoa towards the lumen. Stage 8 extends from the time the spermatozoa line the lumen to their complete disappearance from the lumen. Based upon examination of 80 tubules in each of 10 testes from five Dutch-belted males the percentage of tubules in Stages 1 through 8 were 30.2, 12.3, 7.2, 9.0, 5.5, 16.7, 11.2, and 8.3, respectively. The proportion of cell types occurring in each of the eight different stages also was determined.

329. ORALLY ACTIVE PROGESTIN IN THE HORMONAL CONTROL OF REPRODUCTIVE ACTIVITY IN THE CYCLING AND ANESTROUS EWE. J. F. Wagner* and Leon F. Bush, *South Dakota State College, Brookings.*

An orally active progestational analog, 6-Chloro Δ^6 17-acetoxy progesterone (CAP), was used to inhibit estrous activity in the cycling ewe and as a treatment subsequent to pregnant mare serum (PMS) injection to induce reproductive activity in the anestrous ewe. The lowest of three levels (25 mg./day/ewe) of CAP fed for 16 days inhibited estrous and ovarian activity. Upon withdrawal of the hormone, no synchronization occurred; however, 24 of 27 ewes showed estrus within 60 days after hormone withdrawal. Anestrous ewes (52) were fed three levels (5, 10 and 20 mg.) of CAP/day; one control lot was injected daily with 10 mg. progesterone in oil. Treatment was followed by 1,000 I.U. of PMS on the 17th day; one-half the ewes on each treatment were injected with 750 mcg. of the Na-salt of estradiol 36 hours later. Of those treated with CAP only the 5 mg. group (six of seven) receiving estradiol, came into heat within a 2-day period, compared to 12 of 13 ewes in the control group. Laparotomy indicated reduced ovarian response to PMS in the CAP treated ewes. In most ewes observed, ovulation had not taken place. Anestrous ewes fed 4 levels (1, 2, 3 and 4 mg.) of CAP were treated with 1,000 I.U. of PMS. One-half of each group received 500 μg. of estradiol. Overall, 45 of 50 ewes receiving supplemental estrogen came into heat as compared to 31 of 48 which did not receive estradiol. All ewes came into heat within a 2-day period.

330. SYNCHRONIZATION OF ESTRUS IN GILTS WITH AN ORALLY ACTIVE PROGESTIN. J. F. Wagner* and R. W. Seerley, *South Dakota State College, Brookings.*

One hundred and eighteen breeding gilts were used in three different trials to test the effectiveness of an orally active progestin (Syntex RS-1280, 6-chloro Δ^6 17-acetoxy progesterone—CAP) in inhibiting reproductive activity. The degree of synchronization of reproductive activity was studied after the hormone was fed for 18 days. Vasectomized boars were used to establish the reproductive cycles of gilts prior to treatment. During and after treatment, fertile boars were placed with the gilts daily. CAP was fed at levels of 3.25, 16.5, 25.0, 32.5, 50.0, 97.5, and 540 mg./gilt/day. Estrus periods were inhibited by 16.5 mg./gilt/day; however, follicular growth was not entirely inhibited at this level. Treatments of 25, 32, and 50 mg. gave both inhibition of estrus and follicular growth. Eleven of 16 gilts given the 25 or 32 mg. level came into heat 3 to 7 days after CAP withdrawal. The gilts were bred, but did not conceive. On the 25th day after the withdrawal of CAP five of eight gilts were bred. Slaughter data showed they were pregnant. In another trial at the 25 mg. level six of eight gilts came into heat within a 3-day period. Four were bred at the first service and two at the second service 20 days later. At the 50 mg. level four of eight gilts were bred within a 4-day period 25 days after CAP withdrawal. Twenty percent of the treated gilts had cystic follicles 5 days after withdrawal of the hor-

mones. Most of the gilts with cystic follicles were among the higher treatment levels.

331. EFFECT OF DIETARY NITRATE ON THYROID AND ADRENAL GLAND WEIGHT. C. Welsch*, R. A. Bloomfield, G. B. Garner and M. E. Muhrer, *University of Missouri, Columbia.*

Twenty 300-gm. female rats were divided into two groups of 10 rats each and fed a corn-soybean oil meal diet (calculated iodine level 72 ppm). To one group, 2.5% KNO_3 was added to the diet and to the other, 1.8% KCl was added to attain equimolar potassium levels. The diets were offered to the rats *ad libitum* for 30 days. At the end of this period, the rats were sacrificed. The thyroid and adrenal glands were removal and weighed. Thyroid and adrenal gland weights are expressed as mg. of organ tissue/100 gm. of body weight. The rats with KNO_3 in the diet developed significantly larger thyroid glands than the KCl group; 8.58 ± 0.78 and 5.36 ± 0.38 ($P < .005$) respectively. The adrenal glands were larger in the KNO_3 group but the differences were not significant; 24.08 ± 2.19 and 21.25 ± 1.38 respectively. This was repeated using 14 young rats weighing about 100 gm. These rats were maintained on the above diets for 75 days before sacrificing and weighing the glands. Rats consuming the KNO_3 diet had significantly higher thyroid weights than those on the KCl diet; 12.30 ± 0.74 and 8.35 ± 0.36 ($P < .001$) respectively. The adrenal weights for the KNO_3 and KCl groups were 20.74 ± 1.58 and 21.37 ± 1.10.

332. PROBLEMS IN SUCCESSIVE HORMONAL INDUCED LACTATION. Ralph Williams* and C. W. Turner, *University of Missouri, Columbia.*

Successive experimental lactations were attempted in 19 hormonal induced lactating animals by daily injecting 200 mg. progesterone (P) and 200 mcg. estradiol benzoate (EB) for 180 and 120 days followed by 0.3 mg. EB/100 lb. body wt. for 14 days. Treatment for 180 days in four cows caused only a temporary increase up to 4.0 lb./day, which declined to or below the level secreted before EB treatment. Six of the eight heifers dry 30 days of the 120-day treatment period produced a maximum daily milk yield of 0.3 to 8.5 lb. with a mean of 4.2 lb./day within 5 weeks. Two failed to lactate. Three animals milked throughout the treatment showed an increase of 0.4 to 3.9 lb. with a mean of 2.2 lb./day, whereas the average yield for the group of seven continued to decline following the EB treatment. Injections of decreasing amounts of P (150 to 50 mg.) and increasing EB (1 to 3 mg.) were then administered to eight dry and seven lactating cows for 60 days, which failed to show increased production after the 120-day constant level P-EB treatment. The dry cows were stimulated to produce an average maximum yield of 17.2 lb./day ranging from 8.7 to 31.4 lb., whereas the lactating group showed an increase of 0.0 to 28.9 lb. with a mean average maximum yield of 15.9 lb./day in 6 weeks. Three heifers which had produced an average of 4.3 lb./day after a 60 day P-EB treatment responded to the alternating level with a maximum average of 13.5 lb./day. With one exception, alternating levels of P-EB proved better in stimulating a successive experimental lactation.

333. TRANSFER AND VIABILITY OF ONE-CELL OVA IN SHEEP. C. O. Woody*, G. W. Alliston and L. C. Ulberg, *North Carolina State College, Raleigh.*

A technique for the transfer of one-cell ova was deemed necessary for the further study of the effect of high temperature on embryo survival in sheep. Forty follicular ova were obtained during estrus and deposited into the oviducts of previously mated ewes and in 24–48 hours these ova were recovered to determine fertilization. No ova developed beyond having two polar bodies (in two ova). Three of seven cleaved ova (controls) resulted in pregnancies. Transfer of ova soon after ovulation was then attempted in controlled estrus ewes. Onset of estrus was synchronized within 12 hours in 17 of 23 pairs. One ewe of each pair was mated; ova were recovered from the oviducts of both ewes approximately 24 hours after the onset of estrus; reciprocal transfers were made and, initially, ova were examined for cleavage 24–28 hours later. Of 12 unfertilized ova transferred into mated ewes, eight were recovered 24–48 hours later, of which six had cleaved. These six ova were redeposited and one resulted in pregnancy. Of nine ova obtained from mated ewes and deposited into non-mated ewes, six were recovered 24–48 hours later, of which three had cleaved. None of these resulted in pregnancy when redeposited in the uterus. Transfer without a cleavage check was made with 4 unfertilized ova and resulted in two pregnancies and a possible degenerating embryo. Similar transfer of five ova from mated ewes resulted in one pregnancy. Seven cleaved ova (controls) resulted in two pregnancies and a possible degenerating embryo.

334.

335. EVALUATION OF VARIOUS MATERIALS AND METHODS OF APPLICATION IN THE CONTROL OF *MUSCA AUTUMNALIS* (Face Fly). C. K. Dorsey and H. E. Kidder*, *West Virginia University, Morgantown.*

Face Fly control studies conducted in 1960 and 1961 involved the use of spray, dust, and smear formulations. The materials tested included Diazinon, Co-Ral, Ruelene, Korlan, Dylox, Dimethoate, Malathion, Pyrethrenins, Methoxychlor and Sevin. The smear formulations were neither practical nor effective and most of the sprays were ineffective in controlling face flies. Certain organophosphorous dust formulations (Diazinon and Co-Ral) gave good control for two weeks. Diazinon as a 0.1% spray was effective in protecting the experimental cattle for 3 weeks.

335a. INVITATIONAL PAPER—DESIGN CRITERIA AND MANAGEMENT FOR MANURE DISPOSAL LAGOONS. H. J. Eby, *University of Maryland and U.S.D.A., College Park.*

336. DESIGN OF EXPERIMENTAL FACILITIES FOR FEEDING CATTLE. Lorin E. Harris*, *Utah State University, Logan.*

Basically a facility for feeding experimental cattle should include the following: (1) shed for the ani-

mals to bed; (2) a hard surfaced yard between the bedding area and the manger; (3) a manger for feeding separate from the bedding area and; (4) under some conditions it may pay to have the feed stored in front of the manger. The shed for bedding the animals and a cover for the manger and feed should slope away from the hard surfaced area so moisture will not run into this area. The hard surfaced area should be sloped to drain properly. Stanchions are not necessary for individual feeding or for feeding small groups of cattle. With properly arranged gates and no stanchions manure can be moved mechanically. The hard surfaced yard is cleaned once or twice a week and the bedding area once a year. This basic design is applicable for keeping one animal per pen or small groups in replicated pens. The animals can be fed in a group or individually by tying up (least preferred method) or they can be fed in an individual manger in an individual pen. Maternity pens also fit this basic design. To prevent cattle from consuming bedding fit them with a muzzle. It may be desirable to put the cattle on slatted floors. This has the following advantages: (1) labor is saved in bedding and cleaning; (2) animals have more freedom, comfort, and a warmer bed; (3) animals are not bedded on a cold cement floor or in a stall; (4) feed can be moved directly from storage or truck to manger; and (5) the yard and shed can be cleaned with power machinery.

336a. INVITATIONAL PAPER—ENVIRONMENTAL CONTROL, HOUSING, AND SPACE REQUIREMENTS OF SWINE. H. H. Heitman, Jr., *University of California, Davis.*

336b. INVITATIONAL PAPER—LIVESTOCK AND THEIR ENVIRONMENT. H. D. Johnson, *University of Missouri, Columbia.*

337. CONTROL OF CATTLE GRUBS BY POUR-ON, INJECTION AND SPRAY. Paul H. Kohler* and Wm. M. Rogoff, *South Dakota State College, Brookings.*

Over 500 calves were treated for the control of cattle grubs, *Hypoderma lineatum* and *H. bovis*, with one of four systemic organophosphate compounds: Ruelene (4-tert.-butyl-2-chlorophenyl methyl methylphosphoramidate), Co-Ral (o-(3-chloro-4-methylumbelliferone) 0,0-diethyl phosphorothioate), Bayer 29493 (0,0-dimethyl 0-(4-methyl-thio-m-tolyl) phosphorothioate), or American Cyanamid 38023 (0,0-dimethyl, p-(dimethyl sulfamoyl) phenylphosphorothioate). Single dose administration was by intramuscular injection, pour-on (100–250 ml. of aqueous or oil suspension poured down the back line), or high pressure spray. Grub reduction comparisons were made between compounds, methods of treatment and at various dosages. Grub infestations in the untreated lots averaged 10.5 to 37.2 per animal. Seven lots treated with Ruelene via the pour-on method reduced grub numbers 99–100% at 10 or 7 gm. and 90–96% at 5 gm./animal. Four lots similarly treated with Co-Ral in oil at 5 gm./animal showed 36–95% reductions, with the higher control associated with lower viscosity, and one lot treated with 38023 at 10 gm./animal demonstrated 95% reduction. Injection with 38023 at 15 or 7 mg./kg. or with 29493 at 7 mg./kg. yielded reductions of 99–100%. Spray treatments at 0.25% with Ruelene, Co-Ral, or 29493 showed reductions of 100, 91, and 100% respectively. At 21 days post-treatment, red-blood-cell cholinesterase activity of the treated groups ranged from 58 to 96% of their average pretreatment levels. Average weight gains for the lots on the high-energy ration used over the 119-day test period varied from 3.14 to 2.60 lb. per day with the untreated lots averaging 2.80 lb.

338. MANAGING EWES AND LAMBS TO INCREASE PRODUCTION AND CONTROL PARASITES. J. M. Lewis*, M. E. Mansfield, F. C. Hinds, *University of Illinois, Dixon Springs Experiment Station, Robbs.*

Various systems of managing ewes and lambs were evaluated with respect to their ability to promote rapid and economical gains, produce a desirable market lamb, allow twins to gain as rapidly as singles and effectively control internal parasites. The systems of management were as follows: (1) Ewes and lambs on nitrated orchard grass (NOG), lambs with creep (2) Duplicate groups of lambs self-fed in drylot, ewes on pasture (NOG) during the night and returned to the lambs during the day (3) Ewes and lambs on pasture (NOG), no creep (4) Duplicate groups of ewes and lambs on legume-grass pasture, lambs with creep (5) Duplicate groups of ewes and lambs on legume-grass pasture, no creep (6) Lambs weaned after varying periods on pasture with the ewes as in 1, 3, 4 and 5 above. In so far as possible, equal numbers of single and twin lambs were used in each lot. The data suggest that internal parasite infestations can be effectively controlled (as measured by fecal egg counts and hematocrits) when lambs are not allowed to pasture with the ewes. Creep appeared to improve the gains of lambs on both types of pastures. As previously reported, the in and out system was equal or superior to any other system of management studied with respect to the criteria used. In contrast to previous work at this station, gains on nitrated orchard grass were not as great as gains on legume-grass pastures. Also in contrast to previous work, weaning lambs after varying periods of time on pasture with the ewes did not consistently improve the lambs performance.

339. SOCIAL DOMINANCE IN SWINE. O. G. Rasmussen*, E. M. Banks, T. H. Berry, D. E. Becker, *University of Illinois, Urbana.*

Three experiments were conducted with 36 pregnant gilts to study the occurrence of social dominance. In Experiment 1, in which more than adequate feeder space was provided, there was no evidence of a dominance order. Position of pen mates at the feeding space failed to show a regular pattern. However, in Experiment 2 in which an inadequate number of feeder spaces was provided, the gilts quickly established a dominance order by fighting and biting. This dominance order or "bite order" was determined by ranking individuals according to the number of pen mates bitten by each. In a group of seven gilts, it was observed that one gilt completely dominated all others within the pen, and another failed to exhibit any evidence of aggressiveness (biting). The other gilts in the group clearly arranged themselves in an order between the extremes noted. A third series of observations

were conducted using four gilts from Experiment 2 and three strange gilts. Confirmation of the existance of a dominance order among gilts was obtained. In addition, individual bouts between pairs were observed by introducing two animals into a pen with one feeder space. Again, the observations of the bouts confirmed the rank order previously indicated by observations of the entire group. Thus it appears that there is a definite dominance order in swine which is conditioned by the presence of limited feeder space.

340. RELATION OF MANAGEMENT TO PARASITISM IN TARGHEE LAMBS. James H. Turner* and Grant I. Wilson, *Beltsville Parasitological Laboratory, ADP, ARS, USDA, Beltsville, Maryland.*

Changes in serum proteins, hematocrits, and weights of Targhee lambs raised under three systems of management that resulted in exposure to low, moderate, and high levels of parasitism were studied for 5 months. Each of the three bands was composed of about 115 ram lambs of mixed breeds, from which five Targhee lambs were selected for study. Band I was supplied with feeder pellets and hay in a drylot. Band II was moved at biweekly intervals to pastures not previously grazed by sheep for 1 year. Band III was rotated on recently contaminated pastures. Band I acquired only small numbers of the intestinal threadworm, *Strongyloides papillosus*. Band II showed only minor parasitic infections until August when the large stomach worm, *Haemonchus contortus* became a problem, followed in September by heavy infections of *S. papillosus*. Band III lambs developed marked haemonchosis late in June and acute strongyloidiasis in August. Average terminal gamma globulin percentages were 15, 25.5, and 26 for Bands I, II, and III, respectively. The beta globulin increased to 25% of the total serum protein in Band III, whereas in Bands I and II it increased to 14% and 16%, respectively. The average albumin-globulin ratios of bands II and III fell below 1.0 as the parasite burden increased, but rose gradually to 1.5 and 0.79, respectively, whereas that of Band I rose from 1.2 to 2.1 during the experimental period. Low hematocrit values were apparent early in June in Band III and by August in Band II. These lambs also experienced marked weight losses. The type and severity of infection were confirmed by worm counts at necropsy.

341. THIABENDAZOLE, PHENOTHIAZINE AND "CUNIC" AS ANTHELMENTICS FOR SHEEP. J. A. Welch*, G. C. Anderson, and N. O. Olson. *West Virginia University, Morgantown.*

Thiabendazole (2-(4'-thiazolyl)-benzimidazole), phenothiazine (fine grind, purified) and "Cunic" (copper sulfate and nicotine sulfate) were compared in six flocks. Ten suckling lambs were randomly assigned to each of the above treatments in each of the six flocks. The lambs ranged in weight from 40 to 90 lb. and averaged 60 lb. Treatment was made during the latter half of June. Fecal samples were taken at the time of treatment, 7 days, and 21 days after treatment. Lambs were weighed at the beginning and 21 days later. Dosages were as follows: Lot I, phenothiazine, 20 gm. per lamb; Lot II, Thiabendazole, 44 mg./kg. body weight; and Lot III "Cunic", 1 to 2 oz. per lamb according to weight. Nematode eggs, excluding *Trichuris ovis* and *Strongyloides papillosus*, present in the feces were counted by the Stoll method and are expressed below as eggs per gram of feces (EPG). Average EPG at time of treatment for the 60 lambs on each treatment were: 686, 629, and 580 for lots I, II and III, respectively. At 7 days post treatment, the EPG, expressed as % of pre-dose level, were 8.3%, 1.7% and 25.2%, respectively, for lots I, II, and III. At 21 days post-treatment, the EPG were 43.6%, 28.8%, and 69.3% of the pre-dose level for lots I, II, and III, respectively. Average weight gains for the lambs on each treatment during the 21 days were 9.5, 9.0, and 9.7 lb. per head for lots I, II, and III, respectively. The low level of fecal nematode eggs and the good weights gains indicate a generally low level of parasitism.

342. LABOR REQUIREMENTS UNDER TWO DIFFERENT SYSTEMS OF CONFINEMENT SWINE PRODUCTION. Francis C. Wingert*, E. R. Goldenman and J. W. Nelson, *Cargill-Nutrena Research Farm, Elk River, Minnesota.*

Two complete systems of modern confinement swine production were contrasted in labor requirements over the period from July 1, 1960 through December 31, 1960. In each system, 20 females were mated to farrow 53 days. Breeding stock numbers, feeding and management between the two systems were maintained as uniform as possible. The first system, termed the Central System of Swine Production, is made up of a gestation unit, farrowing-stall farrowing unit, growing unit and finishing unit. The second system, termed the Isolation System of Swine Production, is made up of a gestation unit, individual isolation farrowing units, and a growing-finishing unit. Labor requirements were determined for each unit in minutes on (1) checking and chores, (2) adding feed, (3) bedding, (4) cleaning and hauling manure, (5) steam cleaning, (6) breeding and checking, (7) repairs and maintenance, (8) medical and health, (9) 3-day old treatment and (10) miscellaneous duties. Average labor requirements in minutes per day for each unit over the 184 day period were as follows: (1) Isolation farrowing units—56.4, Central farrowing-stall units—105.0; (2) Isolation growing-finishing unit—58.4, Central growing unit—51.1, Central finishing unit—69.6; (3) Isolation gestation unit—42.4, Central gestation unit—48.2. Average labor requirements in hours per day for each system were: Isolation System—2.62, Central System—4.57. The total labor requirements of the Isolation System of Swine Production were 57.4% of the labor requirements in the Central System.

343. PIG BROODING METHODS, COST AND FUNCTION. F. C. Wingert*, J. A. Johnston, E. Guidarelli, R. P. Gosen and J. W. Nelson, *Cargill-Nutrena Research Farm, Elk River, Minnesota.*

Five types of propane gas-fired brooders (two infra-red and three convection type) and two types of infra-red electric brooders were evaluated over the period from January 10 through April 4, 1960, in Isolation farrowing units. Daily observations were taken in the individual isolation units on: (1)

thermocouple readings at three strategic points 3 or 6 in. above the floor, (2) maximum-minimum thermometer readings (3) meter readings of gas or electricity consumption, (4) apparent pig comfort and well being, and (5) moisture conditions of bedding and walls. Additionally, dead baby pigs of similar weight and color were used to evaluate the radiation effects of the various heating devices via thermocouples placed under the skin, adjacent to the heart and abdominally one inch anterior to the rectum. Two of the gas units proved unsatisfactory and were promptly discarded. Mechanical difficulties eliminated a third gas unit. The remaining four units produced satisfactory results based on all criteria. However, isolation units heated with gas brooders were distinctly drier. Heating costs per isolation unit per 24-hour period were as follows (propane-bottled, 14.5¢/gal.; electricity, 2.5¢/KWH): (1) infra-red gas—12.8¢; convection gas—25.5¢; infra-red electric—38.1¢; 4 250 Watt infra-red bulb electric—53.1¢. The infra-red gas unit proved distinctly superior in heating via radiation. (Isolation unit ambient, 76° F.; dead pig abdominal, 113° F.; outdoor temperature. 30° F.). The infra-red gas unit was also evaluated versus hot water furnace heating for a farrowing-stall type barn.

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NEWS AND NOTES

Meeting of the American Society of Animal Production. The 53rd annual meeting will be held at the Hotel Sherman, Chicago, Friday and Saturday, November 24 and 25, 1961. Registration is from 6:00 p.m. to 9:00 p.m., Thursday, and 8:00 a.m., Friday. Sectional meetings Friday will be held from 9:30 to 11:00 a.m. and a general session at 11:00 a.m. to 12:00 noon. Sectional meetings will continue Friday afternoon, 1:15 to 4:30, and on Saturday 8:45 a.m. to 12:00 noon, 1:15 to 4:30 p.m., and 7:15 to 10:00 p.m. Sectional programs include five sessions in breeding and genetics, 4 in meats, 13 in nutrition, 2 in pasture and forage, 7 in physiology, and 2 in management and facilities. Invitational papers will be given in breeding and genetics, meats, and in management and facilities. In addition, programs in extension and in teaching will be presented both Friday morning and Friday afternoon. The annual dinner and presentation of awards will be held on Friday, 6:00 p.m., and will be followed by the annual business meeting. Your attention is called to the proposed amendment to the constitution, as published in the News and Notes for February and August, which will be voted on at the business meeting. A placement desk will be provided again this year. It is suggested that each prospective employee send pertinent information regarding his training, experience and other qualifications on a 5 x 8 card, to the Secretary. These will be available at the placement desk. Information on job openings will also be welcome. The E. F. Ferrin Portrait Dinner will be held at the Saddle and Sirloin Club, Stock Yards Inn at 6:00 p.m., Sunday, November 26.

The Nominating Committee of the American Society of Animal Production has recommended for presentation at the annual business meeting the following candidates for office: For President, T. J. Cunha, University of Florida; and, for Vice-President, W. D. Gallup, Oklahoma State University and L. E. Hanson, University of Minnesota. The term of office of the present Secretary-Treasurer, C. E. Terrill, Agricultural Research Center, U.S.D.A., does not expire until the end of 1962.

The Western Section of the Society at its annual meeting held July 16 to 18, 1961, on the University of Idaho campus, Moscow, elected the following officers: President, J. A. Bennett, Utah; Vice President, T. D. Bell, Idaho; and Secretary-Treasurer, P. O. Stratton, Wyoming. The 1962 meeting will be held at the University of Wyoming, Laramie.

The North Atlantic Section of the Society at its annual meeting held August 22 and 23, 1961 on the University of Pennsylvania campus, elected the following officers: President, George W. Vander Noot, Rutgers University; Vice President, M. D. Lacy, Cornell University; and Secretary-Treasurer, J. W. Bratzler, Pennsylvania. The 1962 meeting will be held August 21–22 at the Research Center, American Cyanamid Company, Princeton, New Jersey.

A symposium on "Land and Water Use" will be featured at the annual meeting of the American Association for the Advancement of Science, in the Hilton Hotel, Denver, Colorado, December 27–30, 1961. The American Society of Animal Production is a co-sponsor for this program. The symposium is centered on the currently vital topic of the use of public lands, the interrelations of land use with water supply, water managment, and the general welfare of the nation. Half-day sessions will be held on land and water resources, optimum uses for resources, water and climate, impact of public policy on land and water use, and projecting management programs. Dr. R. E. Hodgson, Director of the Animal Husbandry Research Division, Agricultural Research Service, is chairman of the final session which is of particular interest to livestock workers.

The Eighth International Congress on Animal Production, held in Hamburg, June 13–16, 1961, was attended and participated in by 1,113 persons coming from 45 European and overseas countries. The Congress was organized by the European Association for Animal Production and the German Association for Animal Production on invitation of the Government of the German Federal Republic. The Ninth International Congress on Animal Production will be held in Edinburgh in 1966 and will be organized by the British Member-Organization of the European Association of Animal Production.

The 6th International Congress on Nutrition will meet in Edinburgh, Scotland, August 9 to 15, 1963. A series of symposia, addressed by invited speakers will deal with the topics of protein deficiency and its amelioration, dietary factors in the genesis of cardiovascular disease, trace elements in enzyme systems, nutrition in emergent populations, nutrition during early development, absorption of nutrients, preventive and therapeutic diets, endocrine function and reproduction in relation to nutrition, criteria of sound nutrition, balance experiments and isotopes in nutritional investigations and nutrition in relation to health. Short papers reporting original research will be invited from members. Social and sight-seeing events will be arranged for Congress members and their families. Further information can be obtained from The Secretary, 6th International Congress on Nutrition, Department of Clinical Chemistry, Royal Infirmary, Edinburgh, Scotland.

The Second International Congress on Radiation Research will be held in Harrogate, England, August 6–11, 1962. The Congress will be concerned with research into the physical, chemical and biological effects of ionizing radiation. The Radiation Research Society, in cooperation with the NAS–NRC, is exploring possibilities for providing partial travel support to qualified participants. Applications must be submitted prior to February 1, 1962. Forms for this purpose are available from the Committee on Travel Grants, NAS–NRC, Room 319, 2101 Constitution Avenue, N.W., Washington, D. C. Further information about the Congress may be obtained from the Secretary-General, Dr. Alma Howard, Mount Vernon Hospital, Northwood, Middlesex, England.

The Division of Biological and Medical Sciences of the National Science Foundation announces that the next closing date for receipt of basic research proposals in the life sciences is January 15, 1962. Proposals received prior to that date will be reviewed

at the spring meeting of the Foundation's advisory panels and disposition will be made approximately four months following the closing date. Proposals received after the January 15, 1962 deadline will be reviewed following the summer closing date, May 15, 1962. Inquiries should be addressed to the Biological and Medical Sciences Division, National Science Foundation, Washington 25, D. C.

E. F. Ferrin, retired head of the University of Minnesota Department of Animal Husbandry, will receive one of the livestock industry's highest honors on November 26. On that date his portrait will be presented to the Saddle and Sirloin Club of Chicago, to be hung in the organization's world famous gallery. Mr. Ferrin retired from the University staff June 30, 1956, after 36 years of service. At the University he carried on many research projects, including studies of the feeding values of common farm grains for hogs, comparison of protein supplements and antibiotics in hog feeding and studies of full and limited feeding of hogs. Mr. Ferrin is a nationally known hog judge. He is also a member of Minnesota's Livestock Hall of Fame. He has served as a director of the executive committee of the American Pork Producers' Association and was secretary of the Minnesota Swine Producers' Association for 25 years.

George V. Jessup, Jr. has resigned the position of Animal Husbandman at the Southwest Range and Sheep Breeding Laboratory, Fort Wingate, New Mexico, May 13, 1961, to accept a position at the U. S. Army Chemical Corps, Biological Laboratory, Ft. Detrick, Maryland. The vacancy at Fort Wingate has been filled by the appointment of Thomas H. Hall on August 4, 1961. Mr. Hall is a graduate of the New Mexico State University.

Dale Zinn resigned the position of Assistant Professor in the Animal Husbandry Department, New Mexico State University, to accept a position in the Animal Husbandry Department at Texas Technological College, Lubbock, Texas. Professor Zinn has been succeeded by Earl E. Ray, who resigned the position of Animal Husbandman at the Southwest Range and Sheep Breeding Laboratory, Fort Wingate, New Mexico on June 30, 1961.

Milton W. Muldrow, former Arkansas Extension Animal Husbandman, passed away on May 21. Mr. Muldrow retired in July of 1955 after 35 years with the Arkansas Extension Service.

Benjamin T. Dean became Area Specialist in Livestock, Honolulu, Hawaii, on June 15, 1961. He succeeds Clarence L. Moore, resigned. Dr. Dean is a native of Missouri.

Herman W. Westmeyer, a graduate of the University of Missouri, has been appointed Extension Animal Husbandman, July 1, 1961, Manhattan, Kansas.

Joe W. High, Jr. has been appointed superintendent of the Iberia Livestock Experiment Station, Jeanerette, Louisiana, and assumed his duties August 1, 1961. This station is operated cooperatively by the U. S. Department of Agriculture and the Louisiana Agricultural Experiment Station and carries on research work with beef and dairy cattle. Mr. High is a native of South Carolina, a graduate of Clemson College, has an MS degree from the University of Tennessee and has for several years been a staff member of the Animal Husbandry Department of that institution.

Robert S. Temple has been appointed Coordinator of the Southern Regional Beef Cattle Breeding Project, a cooperative undertaking of 13 southern agricultural experiment stations and the USDA. He will be headquartered in the Animal Husbandry Department, University of Tennessee. Dr. Temple is a native of Colorado and since completing his graduate work at Iowa State University has been a member of the staff of the Animal Industry Department at Louisiana State University.

J. H. Conrad, Department of Animal Science, Purdue University, joined the Purdue-Brazil project July 1, 1961. He will teach and do research in Animal Nutrition at Universidade Rural do Estado de Minas Cerais, Vicosa, Brazil during the next two years.

Edward C. Miller, Michigan Extension Animal Husbandman, is on leave for two years, effective May 11, 1961, for service in Taiwan.

Hugh H. Henderson, Michigan Extension Animal Husbandman, resigned June 30, 1961, to accept a position with a commercial firm.

Robert J. Deans was appointed Michigan Extension Animal Husbandman, with headquarters at East Lansing, July 1, 1961. Dr. Deans is a native of Indiana, holds BS and MS degrees from Ohio State and a PhD from Michigan State University.

Robert H. Hines, was appointed Extension Animal Husbandman, June 15, 1961, with headquarters at East Lansing, Michigan. He is a native of Indiana and a graduate of Purdue University.

E. Paul Orcutt, Extension Animal Husbandman, retired June 30, 1961, after 27 years of service with the Montana Extension Service.

Bobby J. Rankin was appointed Extension Animal Husbandman, June 12, 1961, University Park, New Mexico. He is a native of Texas, did his undergraduate work at Texas A and M and received his MS and PhD degrees at Oklahoma State University.

Herbert Brown was appointed Area Swine Specialist, Hopkinsville, Kentucky, September 1, 1961. Dr. Brown is a native of Kentucky, received his BS and MS degrees from the University of Kentucky and his PhD from Iowa State University.

Clarence M. Bradley was appointed Extension Animal Husbandman, Columbia, Missouri, September 1, 1961. Dr. Bradley has been on the teaching and research staff of the Animal Husbandry Department at the University of Missouri for over nine years. He earned his BS and MS degrees at the University of Missouri and his PhD from Oklahoma State University.

David G. Spruill was appointed Extension Animal Husbandman, Raleigh, North Carolina, August 1, 1961. Mr. Spruill is a native of North Carolina and received his BS and MS degrees at North Carolina State College. His subject matter responsibility will be swine production.

Arthur L. Eller, Jr. was appointed Extension Animal Husbandman, Blacksburg, Virginia, September 1, 1961. Mr. Eller is a native Virginian and a

graduate of VPI. He has served in county agent work in Virginia since 1955.

C. R. Cooper, Virginia Extension Animal Husbandman, resigned August 21, 1961.

Henry R. Holzman retired as Extension Animal Husbandman from South Dakota, June 30, 1961.

Phil Phar was appointed Extension Animal Husbandman, Morgantown, West Virginia, June 12, 1961. He is a native of Illinois, received his BS at Illinois University and MS at Kentucky University.

John C. Glenn, Ph.D. Oklahoma State University, has recently joined the staff of the Animal Industry Department at Louisiana State University as Assistant Professor in charge of the Sheep Teaching and Research Program.

Noah C. England has joined the Animal Industry Department at Louisiana State University as Assistant Professor in charge of the Beef Cattle Breeding Program. He replaces Robert S. Temple, who resigned to become Regional Coordinator of the S-10 Breeding Project.

Frank B. Morrison Hall, Cornell University's $4,500,000 animal husbandry building, was formally dedicated September 12 and 13. The new building, of natural brick and limestone, contains over 300 rooms in approximately 133,000 square feet of floor area. Included are offices; six lecture rooms, with one seating 314; five teaching laboratories; 20 research laboratories; two conference rooms; small animal quarters; and special rooms for X-ray studies, small and large animal surgery, microbiological assays, and electronic data processing. A seminar room, reading room, and library are located on the building's third floor. Of special interest in the meat studies area is the modern slaughter floor, a carbon dioxide hog immobilizer for humane slaughtering, a $10,000 temperature-humidity controlled smokehouse, and a meat sales room.

Physiology of Reproduction and Artificial Insemination of Cattle by G. W. Salisbury and N. L. Van Demark; 639 pages, 171 illus; 73 tables; $12.50; W. H. Freeman and Company, San Francisco, California, 1961. The purpose of this book "is to provide a reference source for cattlemen, artificial insemination technicians, and veterinarians, . . .; persons preparing for careers in this field; researchers and scientists in this and in related biological fields; and practitioners of human medicine or in related biology who seek to control reproduction in other species." There are eight chapters on the basic reproductive processes; ten on the chemistry, physiology, technical control, and insemination of male gametes; and five on problems and successes in cattle reproduction.

Radioactive Isotopes in Biochemistry by Engelbert Broda, University of Vienna. 376 pages; 33FL; Elsevier Publishing Co., New York. 1960. This book, which has been translated from the original German, is an excellent addition to the library on the uses of radioactive isotopes. It does not pretend to be an exhaustive study of all of the uses of the radioactive elements in biochemistry. Rather, after a brief historical survey, and a brief evaluation of radioisotope methods, it is devoted to giving examples of different ways in which radioisotopes may be used. This technique gives the reader a feeling for the broad scope of the use of radio elements in biochemistry. At the same time, the reader cannot escape the inevitable conclusion that biochemistry undergirds the fields of animal science, plant science, and microbiology. After discussing the principles of radiochemistry and radiosynthesis, consideration is given to isotope effects, radiation chemistry and radiation biology, with procedures for protection against radiation. One of the most extensive chapters gives both theoretical and practical considerations to problems of measuring radioactivity. After a chapter on the use of radioactivity in the analysis of living matter, including activation analysis and absorption analysis, Dr. Broda devotes a large portion of the book to the discussion of intermediary metabolism. He considers absorption and excretion of elements in both plants and animals, and discusses the field of intermediary metabolism from phosphorylation to nucleic acids. He introduces topics concerned with biosynthesis of heme, cholesterol, and lignin. One feature of this book of particular value to animal biochemists is a reference list of particular pertinence to this field. This book will be of interest to those who have competence in biochemistry and in the use of radioactive elements in that it may call their attention to certain aspects of the field which they may have overlooked in their concentration in a given area. Its greatest value will be to the investigator who uses radioisotopes casually in a research program directed along more conventional lines. Such investigators may find clues to ways in which the techniques of radioactive isotope investigations may be applied to their own fields. G. K. D.

The Merck Veterinary Manual, Second Edition; 1624 pages; $9.75 U. S., Merck & Co., Rahway, New Jersey, 1961. This comprehensive handbook contains extensive information on animal diseases, nutrition, and toxicology of pesticides and other poisons. Chapters on management and disease problems of fur, laboratory and zoo animals have been reworked and enlarged. Laboratory procedures are given in an addendum. The entire list of prescriptions are grouped in one section. A complete subject index with many cross references is provided.

November 15, 1961, marks the 90th birthday of Professor Dr. Erich von Tschermak, Vienna, Austria. Professor von Tschermak is the last survivor of the three rediscoverers (in 1900) of Gregor Mendel's work (published in 1866) which formed the foundation of the science of genetics. Professor Tschermak's recollection of the birth and early childhood of genetics are given in: "The rediscovering of Gregor Mendel's work," J. Heredity 42:163, 1951, in which this interesting remark is made: "the three rediscoverers were less interested in being celebrated as rediscoverers of rules they themselves designated 'Mendel's Laws', than in the successful utilization of these laws for the development of their various fields: de Vries for the mutation theory, Correns for fundamental research in inheritance, and I for practical plant breeding". English translations of "The 1900 'rediscovery' papers by de Vries, Correns and Tschermak" and "Mendel's letters to Nägeli, 1866–1873" may be purchased, under the title "The Birth of Genetics", from Genetics, Experimental Science Building 122, The University of Texas, Austin 12, Texas (Price $1.00, payable to Genetics, Inc.).

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